Cabot Supermetals, Inc.
2003 Decommissioning Cost Estimate
for the Boyertown, Pennsylvania Site

Prepared by:

Weston Solutions, Inc.

Approved by:

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~~July~~ December 11, 2003

EXECUTIVE SUMMARY

Weston Solutions, Inc. (WESTON®) is providing a cost estimate for decommissioning the Cabot Supermetals, Inc. (CSM) Boyertown, Pennsylvania site. The cost estimate is based on a survey that was performed by the Scientific Ecology Group, Inc. (SEG) in 1993 (Reference 6.1); however, the estimate has been updated to reflect current decommissioning standards and unit costs. Conversations with CSM's Radiation Safety Officer indicate that no major spills or changes in configuration have occurred since 1993; therefore, the SEG information was used with certain minor modifications to estimate the radioactive materials presently on-site. WESTON then updated the cost estimate, following cessation of site operations, for site characterization; equipment, tank, concrete, and soil decontamination; radioactive waste volume reduction, packaging, shipping, and disposal; health physicist support; and final release surveys. The updated cost estimate is $5,894,248, which reflects typical 2003 costs and incorporates a 15% contingency. The 15% contingency is less than the standard value (25%) used by the U. S. Nuclear Regulatory Commission, but is justified by the following conditions:

- CSM has established a contract with IUC in Blanding, Utah for the transportation and disposal (T&D) of the presscake that is stored in the bulk storage bins. The costs associated with T&D of the presscake represent 88% of the total T&D cost in this estimate ($4,341,044), and more than half of the total cost ($5,894,248). Having a firm contract price reduces the ambiguity that accompanies the use of generic "book" rates for T&D services and makes a smaller contingency factor reasonable.

- The presscake is contained in bulk storage bins on-site and is produced at a consistent rate during plant operation, so the material to be disposed is always separate from clean soils and other plant materials and its quantity is precisely known. This virtually eliminates any uncertainty in the quantities of presscake for T&D, making it unnecessary for contingency on the largest variable in this cost estimate.

- The second largest quantity in the T&D estimate, the contaminated soils, were estimated conservatively by extending the area and depth for excavation beyond the points at which contamination was within the applicable cleanup limits. The need for a large contingency is reduced by broadly overestimating the area and depth of excavation.

- The approach to estimating costs is generally as would be performed by a contractor developing a construction bid. All labor is assumed to be performed by private contractors at rates that include at least a 10% profit margin.

- The estimate is detailed and conservative in many of its assumptions, thereby limiting the potential for omitting relevant expenses.

- The conditions at the site are well known, the site has no periods of unknown or uncontrolled operations, and the site owners/operators have generally complied with regulatory requirements.

- The quantities of licensed radioactive materials and the site areas where they are handled are small compared with many industrial operations such as uranium mills. This limits the potential for significant costs to be overlooked.

This estimate is for budgetary purposes only and is not a proposal or cost estimate for WESTON to perform work. Cleanup limits developed for this document are intended for cost estimating purposes only and are not intended for use as license termination criteria.

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ATTACHMENTS

1. INTRODUCTION

1.1 PURPOSE

Weston Solutions, Inc. (WESTON®) prepared this document to provide an updated cost estimate for decommissioning the Cabot Supermetals, Inc. (CSM) Boyertown, Pennsylvania site (Boyertown site). The cost estimate includes those activities and cost factors, including a significant contingency factor as required by the Nuclear Regulatory Commission (NRC), applicable to removing residual radioactive material to levels that will allow release of the site for unrestricted use in accordance with NRC guidelines (See Reference 6.2, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, and Reference 6.3, *Draft Consolidated NMSS Decommissioning Guidance: Decommissioning Process*). Costs associated with the demolition and removal of non-contaminated equipment or structures are not included in this cost estimate. The date of actual decommissioning is not known or projected, as this facility is expected to continue operation for an extended period of time. The costs listed in this report are estimates based on typical 2003 costs for contracted services. The cost estimate in this document should be used for budgetary purposes only and does not constitute a proposal or cost estimate for WESTON to perform the work. Cleanup limits developed for this document are intended for cost estimating purposes only and are not intended for use as license termination criteria.

1.2 SCOPE

The scope of this report is limited to the derivation of the cost required to remove residual radioactivity after cessation of operations at this site. Costs, in 2003 dollars, include the following:

- Costs of site characterization after site operations have ceased and all stores of licensed material have been removed from site.
- Costs of manpower and equipment to remove or reduce residual radioactivity to levels that will permit release for unrestricted use.
- Costs of radioactive waste packaging, volume reduction, transportation, and disposal.
- Costs of final site release survey.
- Applicable sales tax for contracted activities, and a contingency amount as would be applied in a construction cost estimate.

1.3 DISCUSSION

This cost estimate represents an evaluation and study of the costs for the decommissioning and disposal of the radioactive portions of the CSM Boyertown site. The methodologies specified for decontamination and demolition were selected to minimize the decommissioning cost. This study is based on the physical condition of the Boyertown site as of 2003, data from routine contamination surveys performed under CSM's radiation protection programs, data from CSM ore analyses, data from a site survey performed by WESTON in January 2003, and information in the most recent decommissioning cost estimate prepared by the Scientific Ecology Group, Inc. (SEG) (Reference 6.1). The result of this study is a decommissioning cost estimate of $5,894,248, which represents a 49% increase over the amount in the 1993 cost estimate. The bases of the cost estimate are clearly documented in a concise spreadsheet calculation that can be easily updated. The following list of assumptions and bases were utilized in developing the cost estimate.

1. All stored ore will have been processed or removed from the site by CSM prior to the start of decommissioning. Removal and disposal of the presscake stored in the bulk storage bins is included as a task in this estimate.

2. All operating areas will have been cleaned to remove loose ore dust and presscake from equipment and structures.

3. The disassembly and decontamination of slightly contaminated equipment will be performed on-site utilizing contract labor including health physics and decommissioning project personnel.

4. On-site decontamination of equipment will be performed where possible.

5. Off-site volume reduction facilities may be used to minimize radioactive waste volume.

6. Contracted on-site soil segregation techniques or soil washing methods will be used to minimize radioactive soil waste volume.

7. Automatic data logging equipment will be used in the performance of site release surveys.

8. Licensed disposal sites will be used for disposal of wastes that exceed unrestricted release criteria and unimportant quantity source material, as defined in 10 CFR 40.13. Currently, EnviroCare and Waste Control Specialists, Inc. (WCS) are designated to accept such material from the site.

9. Residual source material that meet acceptance criteria will be transferred to a uranium mill or transferred to another licensee for further processing.

10. Cleanup and release activities will be conducted without generating any mixed wastes (chemical hazardous waste mixed with regulated quantities of radioactive material). This is reasonable because waste minimization processes will be employed, and the low levels of radiation at the site and the known characteristics of the materials handled are unlikely to result in a mixed waste.

11. Volume reduction factors that were used in the 1993 cost estimate and accepted for this site by the NRC continue to be valid.

12. Dimensions of structure and inventories of equipment developed for the 1993 cost estimate are valid because the operations have not been significantly changed since that time and no new buildings have been constructed in affected areas.

2. GENERAL SITE DESCRIPTION

The CSM facility at Boyertown, Pennsylvania, prepares tantalum and columbium (niobium) products for use in several U.S. industries. Chemical processes are used to recover the product materials from ores and slags that contain uranium and thorium. Other operations in the Boyertown facility include fabrication of products, treatment of acidic wastewaters, and storage of presscake containing the uranium and thorium contaminants. The concentrations of the uranium and thorium contaminants are such that they exceed the 0.05% by weight criterion of 10 CFR 40 and must be licensed and controlled in accordance with the requirements of the NRC.

The current operations involving source material are concentrated in two areas of the 160-acre site. The production area is located in the southeastern part of the site (on both sides of County Line Road), and the wastewater treatment plant, bulk storage bins, and principal raw material storage areas are located northwest of the production area. The remainder of the site consists of approximately equal areas of deciduous trees (e.g., oak, hickory, maple, elm, and ash) and open field (grassland and corn).

The licensed radioactive materials impact only a few of the many buildings on-site and very limited parts of the total site area. A diagram of the site indicating the areas where licensed materials are present is provided in Appendix A.

3. DESCRIPTION OF THE DECOMMISSIONING METHOD

The decommissioning method presented in this section is taken primarily from Reference 6.1, *Decommissioning Cost Estimate for Boyertown, Pennsylvania Site.* This method requires that residual radioactive materials be removed after termination of operations at this site. For the purposes of this cost estimate, once structures and soils are decontaminated to releasable limits, no further decontamination or demolition is required.

When the site operations cease, it is assumed that unprocessed ore remaining on-site and the presscake in the bulk storage bins will be removed and disposed off-site. It is further assumed that ore exists in original shipping containers and will be trucked off-site for disposal or transfer to another licensee. Thoroughly cleaning equipment, building surfaces, and all other external and internal areas will remove residual material.

The following areas are considered for decommissioning in this cost estimate because they contain radioactive material or have previously contained radioactive material.

3.1 BUILDING 73

Grinding equipment is operated in an enclosed system within Building 73. The fine ore and slag particles from the grinding process are collected and segregated according to particle size with an air classification system. The effluent is cleaned in a baghouse that operates at a pressure slightly lower than that of the building.

With the exception of the outdoor presscake storage pad, surrounding outdoor areas, and underground drain pipes, all of the equipment and electrical boxes in Building 73 are assumed to contain ore dust. The ore dust is a loose material that is expected to be removable to release limits by conventional cleaning methods. The first step in the cleanup would be to perform a general cleaning of these areas, using appropriate equipment.

Electrical boxes, control panels, and other miscellaneous items from the walls of Building 73 will be compacted prior to disposal at a licensed facility. The Digester Area, Filter Area, Outdoor Scrubber Area, and Outdoor Feed Tank Area contain process piping and equipment that requires flushing and wipe down prior to survey and release (most of this piping is plastic or plastic-lined). The smaller pipe sizes may not be accessible for surveying and may be compacted for disposal.

The surfaces of metal ceilings and/or cinder-block walls will be vacuumed and wiped down prior to survey and release. In some areas the cinder-block walls have large open holes in the blocks. Additional holes will be made in these blocks to allow the dust to be vacuumed from within the blocks. For areas with corrugated fiberglass wall panels, the walls will be vacuumed, brushed, and wiped prior to survey and release. The concrete surfaces or floors and bases will be vacuumed and then scabbled to remove approximately 1/2 inch of concrete. The cracks will then be chipped out to remove contamination as necessary prior to surveying for release.

3.1.1 Grinding Area

Ore is ground in the Grinding Area in Building 73. The general cleaning outlined above would be followed by disassembly of the grinders, conveyors, hoppers, and support structures. This equipment would require further vacuum cleaning, brush cleaning, and wipe down prior to survey and release.

3.1.2 Repackaging/Screening Area

Materials are screened for appropriate size and repackaged in the repackaging/screening area, which is part of Building 73. The general cleaning outlined for Building 73 would be followed by disassembly of the drum handler/screener and support structures. This equipment would require further vacuum cleaning, brush cleaning, and wipe down prior to survey and release.

3.1.3 Digester Area

The finely ground ore is transferred, as needed, into the digester tanks containing hydrofluoric acid. The acid selectively dissolves tantalum and columbium to form fluorotantalic acid (H_2TaF_7) and fluoroniobic acid (H_2NbF_7). The uranium and thorium contaminants react with the acid to form the insoluble compounds, UF_4 and ThF_4. Aluminum, calcium, magnesium, and potassium also react to form insoluble fluoride compounds. After a sufficient dissolution period, the mixture is passed through filter equipment where the insoluble compounds (containing the uranium and thorium) are removed from the solution and collected for disposal.

It is expected that equipment and floors may have the radioactive contamination strongly bonded as the result of the acid digestion process. Flushing and disconnection of the digester vessels would follow the general cleaning. The vessels have a rubber lining and a layer of graphite bricks inside to resist the hydrofluoric acid. These bricks will have absorbed activity and will need to be removed for disposal. It is expected that the tank lids will be removed and that the graphite bricks will be removed using a long-handled digging bar. The interior can then be flushed, surveyed, and released.

3.1.4 Filter Area

After digestion, the processed mixture is passed through filtration equipment where the insoluble compounds (containing the uranium and thorium) are removed from the solution and collected for disposal. This filtering step includes a press to reduce the moisture content of these solids (presscake) to about 40%. Filtrate is pumped to the metal-recovery process facility (Building 74).

It is expected that equipment and floors may have the radioactive contamination strongly bonded as the result of the acid digestion process. Flushing and disconnection of the filters would follow general cleaning. The disassembled filters can be further brushed and washed to remove contamination prior to being surveyed and released. The walls in the filter discharge area would receive an additional high-pressure wash to remove caked-on material.

3.1.5 Outdoor Scrubber Area

Air emissions are scrubbed in the outdoor scrubber area near Building 73. Flushing and disconnection of the scrubber vessels, piping, and fiberglass ductwork would follow the general cleaning. The disassembled vessels, process piping, and other process equipment would require flushing and wipe down prior to survey and release.

3.1.6 Outdoor Bag Filter Area

The bag filter plenums are located in the outdoor bag filter areas. The general cleaning would be followed by disassembly of the filter system. The disassembled filters, ductwork, and other equipment would require additional vacuum cleaning, brushing, and wipe down prior to survey and release.

3.1.7 Outdoor Compressor and Tank Area

The compressed air system is located in the outdoor compressor and tank area. The compressor is expected to have internal contamination that will not allow it to be surveyed for release. Disconnection and removal of the compressor would follow general cleaning. The pressure tank would be opened and all surfaces would be vacuumed and wiped down prior to surveying for release.

3.1.8 Outdoor Feed Tank Area

The tantalum and niobium-rich liquor that is produced during ore processing is initially transferred to a feed tank area outside Building 73. The cleanup of this area would involve a flush of all the tanks followed by a wipe down of the exterior of the fiberglass tanks. The tanks would then be disconnected and opened to allow brushing and flushing to remove solids caked in the bottoms of the tanks. The tanks would then be removed and surveyed for release.

3.1.9 Outdoor Presscake Storage Area

The presscake from the dissolution and filtering operations is a mixture of $CaAlF_5$, $KMgAlF_6$, CaF_2, $CaMg_2AlF_{12}$, SiO_2, and SnO_2. The presscake also contains residual tantalum and niobium along with a combined uranium/thorium concentration of about 1%. The presscake is temporarily stored in open, portable hoppers on the northwest end of Building 73 until a truckload of containers is filled. The presscake containers are then transported to the bulk storage bins where they are emptied.

Presscake has been in contact with the concrete and asphalt surfaces in this temporary storage area. About half the area is concrete (where the presscake hoppers are staged) and half is asphalt. The cleanup consists of a general high pressure washing of the pad, scabbling the rough concrete surface to remove about 1/2 inch of concrete followed by chipping out the cracks to remove contamination. The asphalt would then be removed for disposal at a licensed facility prior to surveying the area for release.

3.1.10 Roof Top Classifier and Bucket Elevators

Building 73 contains equipment that sorts and transfers ore feed material. A sealed, size-sorting device or classifier is located on the roof, and the bucket elevator transfers scoops of ore to the grinding circuit. These systems would receive a general cleaning that would be followed by disassembly of the classifier system, bucket elevators, and ancillary equipment. This equipment would require additional vacuum cleaning, brushing, and wipe down prior to survey and release.

3.1.11 Surrounding Outdoor Areas

Ore, ore dusts, and presscake have been in contact with areas outside Building 73 due to ore handling operations, grinding operations, maintenance operations, and outdoor presscake hopper storage. Asphalt was added around the building after the building was initially put into operation. The areas not covered by asphalt are covered with a soil composed of gravel and clay that is over one foot deep. Deep soil samples could not be obtained in this area, but it is expected that contamination has penetrated to a depth of about one foot.

The area will be excavated to a depth of one foot. Most of the gravel would be washed to remove contamination, then surveyed and released. The portion of the soil that cannot be decontaminated would be packaged for disposal at a licensed facility prior to surveying the area for release.

3.1.12 Underground Drain Pipes

Outside drains that collect rainwater from the roof gutter system are expected to be contaminated. Floor drains in the building will also be contaminated. These drains will need to be removed and the soil around the drains monitored for contamination. The extent of contamination was not determined for this cost estimate. It is expected that the drainpipes could be located and monitored along their length to determine the extent of contamination. For this cost evaluation, it is expected that 100 yards of contaminated piping buried 4 feet below grade will require removal. It is also expected that 10% of the fill around the pipe is contaminated. The pipe is expected to have absorbed contamination that cannot be removed. The pipe will be removed and disposed at a licensed facility before the area is surveyed for release.

3.2 BUILDING 74

The solutions from the Building 73 filtering equipment are pumped to the processing equipment in the metal-recovery facility, Building 74. The tantalum and columbium are continuously extracted from the solutions by reactions with methyl-isobutylketone (MIBK), followed by sulfuric acid and hydrofluoric acid treatment. This process separates the mixture into two product streams containing either H_2NbF_7 or H_2TaF_7 and a liquid waste (raffinate) stream. The liquid waste stream is an aqueous solution of sulfuric and hydrofluoric acids, with possible traces of MIBK.

The disassembled process piping from the tanks and vessels would require flushing and wipe down prior to survey and release (most of the process piping is plastic or plastic lined). The smaller pipe sizes may not be accessible for surveying and may be compacted for disposal at a licensed facility. As decontamination of the process pumps would not be practical, the pumps would be compacted and packaged for disposal at a licensed disposal facility. The concrete surfaces around the tanks and vessels will be scabbled to remove about 1/2 inch of concrete, cracks in the concrete will be chipped to remove contamination, and the area will be monitored for unrestricted release.

3.2.1 Feed Tank Area

Six fiberglass tanks along the northeast wall, labeled 8A, 8B, 9A, 9B, 10A, and 10B, contain radioactive material, as indicated by elevated radiation readings on the tank bottoms (in the mR/hr range). Because of these readings, it is expected that the floor under the tanks will be contaminated from leakage, but that the general floor area will not be contaminated. Although the floor has an epoxy coating, this coating can be damaged when a tank fails and direct contact with the concrete floor occurs. The first step in the cleanup of this area would be to flush all the tanks and then to wipe down the exterior of the fiberglass tanks. The tanks would then be disconnected and opened to allow brushing and flushing to remove solids caked in the bottoms of the tanks before they are surveyed for release.

3.2.2 Extraction Vessel Area

Two extraction tanks contain radioactive material, as indicated by elevated radiation readings on the tank bottoms (in the mR/hr range). It is expected that the floor under these vessels will be contaminated from leakage, but that the general floor area will not be contaminated. The cleanup of this area would begin with a flush of the vessels followed by a wipe down of the exterior. The vessels would then be disconnected and opened to allow brushing and flushing to remove solids caked in the vessels. The vessels would then be removed and surveyed for release.

3.2.3 Floor Drains

The floor drains for collecting process spills are contaminated and will need to be removed, and the soil around the drains will need to be monitored for contamination. The extent of contamination was not determined for this cost estimate. It is anticipated that the drainpipes could be located and monitored along their length to determine the extent of contamination. For this cost evaluation, it is expected that 50 yards of contaminated piping buried 4 feet below grade will require removal. Approximately 10% of the fill around the pipe may be contaminated. The pipe is expected to have absorbed contamination or have internal contamination that cannot be removed; therefore, the pipe will be disposed at a licensed facility before the area is surveyed for release.

3.2.4 Outdoor Acid Waste Tank Area

Two contaminated outdoor acid waste tanks are situated in an area with a high curb; one of them is abandoned. These tanks read about 500 μR/hr. The cleanup of these tanks would begin with a flush, after which they would be disconnected and opened to allow brushing and flushing to remove solids caked in the bottoms of the tanks. The tanks would then be removed and surveyed for release.

3.3 BUILDING 87

Building 87 is the original digestion and press building that continues to be used for handling radioactive materials. Monitoring activities and potential decontamination will be required in the area when the license is terminated.

3.3.1 Digestion and Feed Area

Ore digestion and liquor extraction originally occurred in the digestion and feed area. The only area of this building that demonstrated measurable contamination was the concrete floor under the digester on the southwest side of the building. The digester and filter press did not have elevated radiation levels. For the concrete floor under the digester vessel, the concrete surfaces will be scabbled to remove about 1/2 inch of concrete and cracks will be chipped out to remove contamination prior to surveying for release.

3.3.2 Warehouse and Digester Area

Materials were stored and the digester was located in the warehouse and digester area. The only area of this building that demonstrated measurable contamination was the concrete floor where drums of ore and a contaminated bucket conveyor belt have been stored. The surface of the concrete floor may require scabbling to remove about 1/2 inch of concrete, and the cracks will need chipping to remove contamination before the area is surveyed for release.

3.3.3 Surrounding Outdoor Area

There is evidence of contamination outside Building 87. The area surrounding the building is covered with a soil composed of a gravel and clay mixture more than one foot deep. Deep soil samples could not be obtained in this area, but contamination is assumed to have penetrated to a depth of about one foot due to the porous nature of the soil.

The soil would need to be removed to a one-foot depth. It is expected that the soil could be washed to remove contamination, surveyed, and released. The remaining soil would need to be packaged for disposal at a licensed facility. The area would then be surveyed for release.

3.3.4 Outdoor Temporary Staging Area

There is evidence of contaminated material handling and equipment storage in the outdoor temporary storage area. The area is covered with a soil composed of a gravel and clay combination more than one foot in depth. Deep soil samples could not be obtained in this area, but contamination is expected to have penetrated to a depth of about one foot due to the porous nature of the soil.

The soil will be removed to a one-foot depth. It is expected that most of the soil could be washed to remove contamination, surveyed, and released. The portion of the soil that cannot be decontaminated would be packaged for disposal at a licensed facility before the area is surveyed for release.

3.4 BUILDING 18, STORAGE BUILDING

Building 18 is a former aluminum foundry building that was converted years ago into a warehouse. Most of the building is used to store drums and bags of ore, empty drums, and some chemicals. The rest of the building is used to store equipment and other operational supplies. The ore containers are sampled in this building.

3.4.1 Ore Storage Area (Building 18)

Ore containers were stored and sampled in the Ore Storage Area. Those activities may have resulted in some spillage of ore onto the floor. However, instrument readings in this building do not indicate that it is contaminated and it will not need to be cleaned prior to release. The cinder-block walls and metal ceiling are expected to be clean. This area will be surveyed for release.

3.4.2 Surrounding Outdoor Area

There is no evidence of contamination outside Building 18. No decontamination is planned for the outside area, which is mostly asphalt. However, the final survey of the outdoor area will include soil samples taken through the asphalt to reveal any contaminated soil that needs to be removed prior to releasing the area.

3.5 BUILDING 10, STORAGE BUILDING

The Storage Building is used to store palletized bags and drums of chemicals and materials produced at the Boyertown site. Some palletized drums and bags of ore are also stored here. There is no evidence of contamination in Building 10. Although no decontamination of this building is planned, a final survey of the area should include deep soil samples taken through the asphalt floor to reveal any contaminated soil that needs to be removed before the area is surveyed for release.

3.6 BUILDING 23, LOADING DOCK

Building 23 has a concrete loading dock with a surface-mounted scale used for weighing ore when it is received. There is no evidence of contamination on this loading dock. No decontamination of the area is planned. The area will be surveyed and released.

3.7 BUILDING 11, DEVELOPMENT LABORATORY (ROOM 17)

This laboratory is used in developing new processes for recovering metals from the contaminated ores and for recovering useful materials from the presscake produced in Building 73. There is no evidence of contamination in the laboratory. No decontamination is planned prior to surveying the area for release.

3.8 BUILDING 41, ANALYTICAL LABORATORY

The Analytical Laboratory includes a sample staging room as well as a wet chemical analysis room that are described below.

3.8.1 Sample Introduction Room

The sample introduction room is used to hold samples before and after analysis. It is anticipated that removal and wiping of all laboratory equipment will remove the contamination. No other decontamination of the area is planned prior to surveying the area for release.

3.8.2 General Laboratory Area (Room 12)

The general laboratory area is used for wet and dry chemical analysis. There is no evidence of contamination in this area. No decontamination is planned prior to surveying the area for release.

3.9 BUILDING 62, WASTE PROCESSING AND TRUCK BED WASH DOWN AREA

The presscake from Building 73 processing is transported to the bulk storage bins in open hoppers on flatbed trucks. During transit, small amounts of the presscake may fall onto the truck bed. After unloading, the truck beds are washed off on an asphalt area attached to the wastewater filter house (Building 62). Asphalt was installed in this area in 1993 and the area exhibited no evidence of contamination at that time. In addition, the wastewater treatment process produces a solid filtercake that is monitored for radioactivity and released off-site during daily plant operations. No decontamination of the area is planned prior to surveying it for release.

3.10 BULK STORAGE BINS

The presscake generated in Building 73 is temporarily stored in open, portable hoppers outside the building until a truckload of containers is filled. The presscake containers are then transported to and emptied into the bulk storage bins.

The presscake has historically been stored in the dedicated on-site bulk storage bins for further processing and/or disposal. This cost estimate includes removing, packaging, and transporting the presscake for uranium recovery processing at a qualified, licensed facility, which is ~~about half as~~ somewhat less expensive ~~as~~ than disposal at a radioactive waste disposal site. The bulk storage bins will be monitored for unrestricted release. Approximately 4,000 tons of presscake were stored at the time of this plan, and that represents the maximum amount of presscake expected to be present at the site because CSM is committed to packaging and disposing of the presscake at greater rate than it is produced to eliminate the need for large-scale storage of the presscake on-site. The bulk storage bins are expected to be used only for minimal short-term storage of the presscake within three years.

Beginning in 2003, CSM ceased accumulating the presscake on-site and arranged for disposal at regular intervals throughout the year. Therefore, the quantity of presscake stored in the bulk storage bins is expected to decrease throughout the remainder of 2003 and will reach and sustain a limited “staging quantity” in 2004 that will be far less than 4,000 tons. This cost estimate includes the costs for transporting and disposing of the current 4,000-ton quantity of presscake. Costs are also included for decontamination of the buildings and removal of the contaminated soils around them.

3.10.1 Buildings 99 and 102

Bulk storage bins 1 through 4 constitute Building 99, and bulk storage bins 5 through 7 constitute Building 102. Before each bin is used, it is refurbished with a seamless liner that wraps 6 feet up each wall and is topped by a sloped concrete floor. The presscake is dumped onto the lined floor of each bulk storage bin as a damp solid.

The buildings are constructed of poured concrete, except the upper areas, which are cinder block. The cinder blocks have been added on most of the walls to reduce the size of the opening between the tops of the walls and the bottoms of the roofs. Windblown rainwater is prevented from entering the bins by louvered vents and plastic weather strips above the gates to each bin. In addition, the entryway to each bin has been pitched such that rainwater is directed away from the entrance. Radioactive material is expected to be strongly bonded to the walls and floors. It is assumed that the presscake will be removed from the bulk storage bins before the decommissioning process begins. The cleanup of the facility would start with a high-pressure wash of the interior ceilings, walls, and floors to remove caked-on presscake. The ceiling and wall areas, including the cinder blocks, would be grit blasted to remove activity and then vacuumed before they are surveyed for release. Prior to surveying the area for release, the concrete surface would be scabbled in two separate passes to remove a total of 1/2 inch of material; then the cracks would be chipped out to remove contamination.

3.10.2 Surrounding Outdoor Area

There is evidence of presscake from the bulk storage bins in the soil outside the buildings. The soil is a clay type, and there are graveled roadways around the buildings and between Building 73 and the bins. Composite surface and deep soil samples obtained in this area indicate that contamination has penetrated to a depth of about 6 inches. This cost estimate assumes that the soil will be removed to a 12-inch depth. It is expected that most of the soil could be segregated or washed to remove contamination, and then surveyed and released. The portion of the soil that cannot be decontaminated would be packaged for transportation to a licensed facility prior to surveying the area for release.

3.11 FORMER TIN SLAG STORAGE AREAS

Tin slag is a black silicate glass with a wide range of particle sizes and irregular particle shapes. This material is the water-quenched waste from the tin smelting process in Malaysian countries and was delivered in 55-gallon drums and stored in a large field north and east of Lagoon 6 and also along the roadway to the bulk storage bins. Some of this slag was seen lying on the surface of the ground n 1993, and radiation levels were elevated throughout the area. The soil is a clay type, and there is a graveled roadway passing through the area to the bulk storage bins. Composite surface and deep soil samples were obtained in this area in 1993, and the area was re-sampled in 2003. Soil excavation along the haul road will include contaminated soils from this area. It is expected that most of the soil would be washed to remove contamination, surveyed, and released. The portion of the soil that cannot be decontaminated and exceeds release criteria would be packaged for disposal at a licensed facility before the area is surveyed for release.

3.12 WINTER STORAGE SLAG PILE

The tin slag in 55-gallon drums was initially stored in an area north and east of Lagoon 6. To avoid problems with obtaining frozen slag from the drums during the winter season, a pile of slag was formerly maintained in an area between Buildings 73 and 74. This area is a concrete pad with ore dust on it and no barriers to keep material from being washed off the pad onto the surrounding soil. Although the concrete pad was decontaminated, monitored, and found to meet release limits in 1993, about 3600 cubic feet of contaminated soil would be removed from the winter storage slag pile area, as stated in the original SEG cost estimate (Reference 6.1). The cost for disposal of that volume of material remains in this cost estimate although the area will not require further monitoring, excavation, or disposal.

3.13 THORIUM DOPING ROOM (BUILDING 29)

In the period since 1993, CSM has established a process for thorium doping of tantalum powder. The process is performed in a small room the size of a walk-in closet, about 7 feet wide by 10 feet long, in Building 29. Thorium is added to tantalum powder in the process through a number of steps. Equipment in the room includes a balance, a drying table that employs a steam heating system to drive moisture, a HEPA vacuum system, and two local exhaust ventilation devices. This room will be decontaminated and the equipment disposed of as contaminated debris.

4. SITE PRELIMINARY CHARACTERIZATION AND DOSE MODELING

The CSM Boyertown site was surveyed extensively by SEG in July of 1993 to gather physical facility and radiological data to support the cost estimate performed at that time. The physical data have not changed, other than the minor adjustments described in the previous sections of this document, such as the addition of the thorium doping process. The radiological measurements performed by SEG included direct beta monitoring of surfaces and direct monitoring of general areas with a μR meter, samples from soil areas that demonstrated elevated dose rate readings, and smears obtained to determine the levels of removable activity. The results of that characterization are considered valid today because there have been no significant changes in the site operations and no unplanned releases of radioactive material since 1993, and because routine radiological surveys conducted by CSM have indicated no significant increases in radiation levels around the site and in work areas. Updated radiological data were obtained for this cost estimate to verify current conditions for comparison with the observations and assumptions in 1993 and to support the development of cleanup criteria. WESTON also reviewed routine survey data that spanned the past several years to ensure that contamination levels had not increased significantly in the work areas since the 1993 characterization was performed.

The supplemental site sampling and monitoring performed in January 2003 by WESTON verified soil contamination levels in pertinent areas of the site, defined background radiation levels (external gamma dose rates and soil concentrations) at the site, and supported computer modeling that established new DCGLs for this decontamination cost estimate. Gamma dose measurements were taken using a Bicron tissue-equivalent microrem meter, and soil samples were collected at ten background locations and about 50 locations in areas that will require cleanup if the license were terminated. Samples were taken at 6-inch intervals to a depth of 2 feet and submitted to a contracted laboratory for isotopic analyses.

The typical raw ore processed at the Boyertown site contains uranium and thorium as contaminants. Table 4-1 shows actual average and maximum concentrations of uranium and thorium in the various ores received at the site during 2001. These data were also used in a recent study to determine recent radionuclide mixtures and calculate revised values such as derived air concentrations. The full set of data is provided as an appendix in the "Review of the Occupational Air Sampling Program at the Cabot Supermetals, Incorporated Boyertown Pennsylvania Plant, June 9 2003" developed by WESTON.

Table 4-1. Average Concentration of Uranium and Thorium in Ore Materials Received by CSM During 2001 (Weight Percent).

	%Th	%U
Average	0.057	0.165
Maximum	1.128	0.647

Thorium-232 has much lower surface activity release limits than natural uranium. As a consequence, the site decommissioning will need to meet the lower release limits. Total alpha activity levels of 1,000 disintegrations per minute per 100 cubic centimeters (dpm/l00 cm^2) and removable activity levels of 200 dpm/100 cm^2 alpha are acceptable for unrestricted release of equipment and material from the site. Structures are assumed to meet the dose-based license termination criteria once total alpha contamination levels are reduced to approximately 50dpm/100 cm^2.

In addition, soil sample activities that exceed background by about 2.5 pCi/g of thorium-232 were considered potentially significant under the 25-mrem/yr dose-based standard. These areas were included in the remediation cost estimate. The total and removable activity limits for equipment and materials are based upon the NRC guidelines in Reference 6.2. Total activity limits for residual surface contamination on structures are based on the DandD Version 2.1.0[1] computer program (Reference 6.4) occupancy scenario simulations. The preliminary soil activity limits also are based on simulations using DandD Version 2.1.0. A thorough characterization should be performed prior to the projected decommissioning and after all radioactive ore has been removed from the site to establish with certainty the areas requiring remediation.

4.1 BACKGROUND DOSE RATES AND SOIL CONCENTRATIONS

Dose rate readings were taken using a µR survey instrument in all areas with the potential for residual activity in 1993. These results are summarized in Appendix 1 of the 1993 SEG report (Reference 6.1). That summary contains survey maps for the various locations and provides the associated instrument readings. The µR instrument was used in determining if elevated dose readings extended into the soil areas surrounding the process and storage buildings. The lower dose rate readings on-site and away from processing were in the range of 5 to 20 µR/hr. A value of 20 µR/hr was established as the background level for that report.

Weston Solutions measured background radiation levels and collected soil samples from two depths at 10 locations on the CSM Boyertown site on 13 January 2003 . The RSO for CSM reviewed the locations that were selected and agreed that they were unaffected by licensed activities, structures, or equipment. A Bicron tissue equivalent MicroRem meter was used to perform the background dose equivalent rate measurements. Results are provided below in Table 4-2. The background value for the CSM plant site is 12 microrem/hour. The soil samples were sent to the Eberline Services Laboratory in Oak Ridge, Tennessee for analysis. Eberline Services analyzed all twenty of the samples by gamma spectroscopy. Ten of the samples were further characterized by chemical separation and analysis. The highest concentration for each radionuclide is provided in Table 4-3. These are the proposed background levels.

[1] In these simulations, it was assumed that people rinse heavily soiled food items with water, therefore DandD Version 2.1.0 parameters MLV (1), MLV (2), MLV (3) and MLV (4) were reduced by a factor of 10 (e.g., to 0.01).

Table 4-2. Tissue Equivalent Dose Rates at Background Locations [a] (microrem/hour)

Location I.D.	Reading on contact with ground surface	Reading at 1 meter above surface
B01	11	11
B02	11	11
B03	11	11
B04	11	11
B05	12	12
B06	12	12
B07	12	12
B08	11	11
B09	12	12
B10	12	12

[a] Background locations 1 – 4 are located in the southwest quadrant of the intersection of County Line Road and Swamp Creek Road. Locations 5 - 7 are located within the plant site fence approximately 235 feet south of the southwest corner of bulk storage bin #4. Location 8 – 10 are located at the southeast corner of the site fence, 100 feet south of County Line Road.

Table 4-3. Background Soil Concentrations

Isotope	Concentration (pCi/g)
Uranium-238	2.0
Uranium-234	1.5
Thorium-232	1.9
Thorium-230	1.6
Thorium-228	1.8
Actinium-228	2.6
Lead-214	1.4
Lead-212	3.6
Lead-210	2.1
Thallium-208	2.1
Potassium-40	43.8

4.2 DIRECT COUNT RATE RESULTS

Beta activity levels were measured by SEG (1993) in all structures and outdoor pads with the potential for residual radioactivity. The results are summarized in Appendix 2 of the SEG document (Reference 6.1), which contains the instrument readings and survey map locations for the various readings. SEG used a count rate meter with a shielded GM detector that was primarily sensitive to alpha and beta activity. In 1993, readings in all areas still being actively used for ore processing exceeded 3,000 dpm/100 cm^2. Such areas would require decontamination.

Readings performed routinely as part of CSM's radiation protection programs indicate that conditions have not changed significantly since the 1993 surveys.

4.3 REMOVABLE ACTIVITY RESULTS

SEG took smears in all structures and outdoor pads with the potential for residual radioactivity. These results are summarized in Appendix 3 of Reference 6.1, which presents the counting results for these smears. Most portions of the ore processing facilities had activity levels exceeding 200 dpm/100 cm^2. Results from routine surveys by CSM support those data, so they are assumed to require decontamination. Readings performed routinely as part of CSM's radiation protection programs indicate that conditions have not changed significantly since the 1993 surveys.

4.4 SOIL SAMPLE RESULTS

During the 1993 survey, SEG took soil samples in areas that they judged were likely to exhibit residual activity. The sample locations were based on historical records and preliminary measurement results. These results are summarized in Appendix 4 of Reference 6.1, which contains the instrument readings and the maps showing the survey locations. Most of the samples were surface composite samples taken within a couple of inches of the surface from within the sample areas. Soil activity levels of greater than the preliminary criterion of ~2.5 pCi/g of thorium-232 were considered significant. Most (31 of 46) of the surface samples were collected from active areas that exceeded the 2.5 pCi/g level. Deep soil samples were taken in areas where the activity level was expected to be well over this criterion. Four out of nine of the subsurface samples did not exceed 2.5 pCi/g of thorium-232. Deep soil samples were not obtained from near Buildings 73 and 74, as the soil was mostly gravel to a depth greater than 6 inches. It is important to note that the high quantities of gravel in some of these areas would allow ore products to penetrate deeper than could occur in the clay soil found in other areas.

In January 2003, WESTON collected soil samples at intervals of 0 – 6 inches and 6 – 12 inches below the ground surface from about 50 locations in potentially contaminated areas of the site. Based on those data, the areas for excavation were delineated and an excavation depth of 2 inches was established. This cost estimate uses soil volumes for excavation and disposal determined using these data.

4.5 URANIUM AND THORIUM CHAIN EQUILIBRIUM DATA

The ore material that is processed by CSM is a physical concentrate of niobium and tantalum minerals. It generally has no prior history of metallurgical extraction or chemical processing, so there is no reason to expect the uranium and thorium decay chains in the ore material to be out of equilibrium to a significant degree. Unprocessed ore material is present in the ore storage areas and ore grinding areas.

There is a mass balance between presscake (fluoride waste solids) and filtercake because the amount of radioactivity in discharged wastewater is negligible. The presscake that is produced by the tantalum extraction process is expected to be slightly deficient in lead-210 and polonium-210 compared to the other uranium decay chain isotopes that are present. Otherwise, the decay chains in presscake should be approximately in equilibrium. The presscake solids are likely to be a surface or soil contaminant in areas containing process equipment, the bulk storage bins, and on the haul road to the bulk storage bins.

Attachment A provides information on degree of equilibrium among principal radioisotopes in soil contaminated by ore material and presscake. Based on the discussion and data in Attachment A, affected soils have activity fractions of 42% Th-232 and 58% U-238. These activity fractions differ from the fractions that have been determined from analytical data used for other studies of site conditions, such as historical determinations of the fractions in ore material, and the most recent ore data that were used to establish a derived air concentration (DAC) based on data from recent ore shipments. Likely reasons for these differences are variations in the ore fractions over the years the plant has operated, and the variability of factors (such as weathering, time, solubility, and leaching) that may have acted on the contaminated soils. For purposes of remediation, these data support the assumption that both decay chains are in equilibrium with their gamma emitting progeny.

Lead-210 and polonium-210 appear to partition slightly into the liquid phase during the extraction of tantalum from the ore material with hydrofluoric acid. The filtercake that is directly disposed at regional landfills was studied in detail during 2002. Filtercake contains lead-210 and polonium-210 in higher concentrations relative to the rest of the uranium decay series.

On average, filtercake has the concentrations provided in Table 4-4.

Table 4-4. Average concentrations of radionuclides in filtercake.

Radionuclide	Average Landfill Sludge (pCi/gram)
U-238	2.33
Th-230	2.82
Ra-226	1.16
Pb-210	17.8
Po-210	8.04
Th-232	0.31
Th-228	0.31

The isotopes that are listed in Table 4-4 are the only ones present in the filtercake in significant concentrations. The *Dose Assessment for Recycling of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania* (Weston Solutions, 2003) presents plots and an extended discussion of the filtercake isotopic data. It concludes that:

- Appreciable amounts of licensed thorium-232 chain radionuclides do not appear to be present in the filtercake,
- U-238, Th-230, Ra-226 and Po-210 concentrations appear to be directly correlated, and
- Th-232, Pb-210 and U-238 concentrations do not appear to be correlated with one another.

Filtercake will not be present on-site to any appreciable degree because its routine disposal at local landfills is necessary for daily plant operations to continue. Filtercake is only likely to be present as a soil contaminant in the immediate vicinity of the wastewater neutralization plant. Radionuclide concentrations would be very low in soils contaminated with filtercake, as indicated by data from samples collected in January of 2003 and presented in Table 4-5. The low levels are reasonable because the filtercake itself has very low concentrations.

Table 4-5. Soil Concentrations Around The Waste Water Filtration Building

	Sample Location I.D.					
	I26-06-061	I26-12-062	I28-06-065	I28-12-066	I29-06-057	I29-12-058
U-238	1.57 ±0.39	NR	0.95 ±0.30	NR	1.92 ±0.55	NR
U-234	1.40 ±0.36	NR	0.53 ±0.21	NR	1.88 ±0.54	NR
Th-232	1.20 ±0.37	NR	0.30 ±0.13	NR	0.46 ±0.23	NR
Th-230	1.37 ±0.40	NR	0.89 ±0.26	NR	1.54 ±0.47	NR
Th-228	1.11 ±0.35	NR	0.27 ±0.13	NR	0.45 ±0.22	NR
Pb-214	2.35 ±0.45	2.39 ±0.31	0.73 ±0.19	1.07 ±0.19	2.39 ±0.36	0.67 ±0.16
Pb-212	3.20 ±0.46	2.30 ±0.30	0.28 ±0.11	1.03 ±0.17	1.26 ±0.24	1.02 ±0.16
Pb-210	3.75 ±0.72	NR	1.73 ±0.55	NR	2.33 ±0.66	NR

4.6 ASSUMPTIONS AND INPUT FOR THE DOSE MODELING: SOIL CONTAMINATION

4.6.1 Future Land Use and Exposure Scenario

The Boyertown site is located on the fringes of suburban Boyertown. Assuming no significant changes from past trends, land use around the site will be industrial or suburban within in the next decade or two. To be conservative, CSM assumes that the future land use will be suburban-residential. Therefore the critical group is assumed to be suburban gardeners.

Suburban-residential land use implies a number of modifications to the standard scenario represented by DandD 2.1.0 (McFadden 2001). Suburban-residential land use typically does not involve raising poultry, livestock, or aquaculture. In addition, commodity crops such as wheat, rye or barley are not typically found in suburban-residential gardens.

4.6.1.1 Average Consumption Rate of Homegrown Produce for the Northeastern U.S.

The Exposure Factors Handbook (EPA 1998) (EFH), Table 13-33 provides regional consumption rates of fruits and vegetables for the northeastern United States. The average consumption rates, Figures 1 and 2 were calculated from the EFH data using Crystal Ball 2000.

Crystal Ball Input for Homegrown Fruit Consumption Rate for Northeastern US.

Consumption Rate (kg/y)	Percentile
0	0
1.04E-01	0.01
5.17E-01	0.05
1.25E+00	0.1
4.54E+00	0.25
9.48E+00	0.5
1.72E+01	0.75
3.89E+01	0.9
7.88E+01	0.95
1.34E+02	0.99
1.48E+02	1

Crystal Ball Results for Homegrown Fruit Consumption Rate for Northeastern US.

Statistics:	Value:
Trials	25000
Mean (kg/y)	18.61
Median (kg/y)	9.72
Standard Deviation (kg/y)	26.26

Figure 4-1. Crystal Ball input and results for the homegrown fruit consumption rate for the northeastern US.

Crystal Ball Input for Homegrown Vegetable Consumption Rates for Northeastern US.

Consumption Rate (kg/y)	Percentile
0	0
3.05E-02	0.01
4.17E-01	0.05
9.35E-01	0.1
5.22E+00	0.25
1.19E+01	0.5
3.60E+01	0.75
8.72E+01	0.9
1.50E+02	0.95
2.30E+02	0.99
2.65E+02	1

Crystal Ball Results for Homegrown Vegetable Consumption Rate for Northeastern US.

Statistics:	Value:
Trials	25000
Mean (kg/y)	33.94
Median (kg/y)	11.94
Standard Deviation (kg/y)	49.35

Figure 4-2. Crystal Ball input and results for the homegrown vegetable consumption rate for the northeastern US.

Based on Figures 4-1 and 4-2, the values input into DandD 2.1.0 were: 19 kg per year of homegrown fruit, 34 kg/year of homegrown vegetables. The homegrown vegetable consumption distribution in Figure 2 includes all vegetables as well as grains. One half of the vegetables are assumed to be leafy for the purposes of running DandD 2.1.0. The grain ingestion rates in DandD 2.1.0 were set to zero since the grain contribution is already included in with the other vegetables in the EFH dataset.

4.6.1.2 Probability Distributions for MLV(1), MLV(2) and MLV(3)

The values of DandD variables MLV(1), MLV(2), and MLV(3) pertain to dry weight soil mass loading on homegrown fruits and vegetables that are consumed by humans. These were not assigned distributions in DandD 2.1.0. Nonetheless, these are very sensitive factors. A distribution for these variables was obtained using the Decisioneering Crystal Ball software package, DandD's dry to wet weight distribution for fruit and the soil adhesion distribution for fresh produce from page 104 of NCRP 129. The NCRP distribution had a geometric mean of 0.001 and geometric standard deviation of 2.2. The wet to dry distributions for leafy vegetables and roots were judged to be very similar to the distribution for fruit, so the MLV that was derived herein for fruit was used for all three.

Crystal Ball sampled both distributions to obtain a series of data pairs (or vectors) of *dry to wet weight* and *fresh produce soil adhesion fraction*. For each vector *i*, Crystal Ball computed a value of MLV:

$$MLV_i = \frac{(\text{fresh produce soil adhesion fraction})_i}{(\text{dry to wet weight fraction})_i}$$

The histogram for MLV, which was obtained from the Crystal Ball report for this simulation, was entered as "continuous linear distributions" for MLV(1), MLV(2) and MLV(3) into DandD 2.1.0. The MLV distributions may be viewed in the DandD reports that are provided in Attachment B.

4.6.1.3 Proposed Soil DCGL Values

Based on these assumptions, the derived concentration guideline (DCGL) values for soil are provided in Table 4-6. The individual DCGL values, which represent a total effective dose equivalent of 25 mrem/year, do not apply independently. Instead, a sum of the ratios would be computed for each survey unit.

Table 4-6. DCGL Values for Residual Radioactivity in Soil

Isotope	DCGL (pCi/g) in excess of background
Thorium-232 equilibrium chain	2.94
Ra-228 + chain	3.48
Uranium-238 equilibrium chain	2.38
Ra-226 + short lived progeny	3.30
Pb-210 + chain	6.56

Net dose equivalent rate DCGL values were estimated using Microshield version 6, Attachment C. One DCGL for soil contaminated by a mixture having a ratio of 42% Th-232 / 58% U-238 would have 1.55 pCi/gram of U-238 and 1.125 pCi/g of Th-232 in equilibrium with progeny. The net isotropic deep dose equivalent rate for this mixture would be 11.3 μRem/hr above background. These values apply strictly for the purpose of establishing a cost estimate for decommissioning and are not intended as a basis for license termination.

4.7 ASSUMPTIONS AND INPUT FOR THE DOSE MODELING: SURFACE CONTAMINATION

DandD 2.1.0 was used to derive surface contamination DCGL values for structures. It is anticipated that structures will be decontaminated to satisfy the DCGL values stated in this section. The structures will then either be re-used or demolished by standard demolition techniques.

All default values are used in the building occupancy scenario calculation, with one exception. An effective indoor resuspension factor, RF_o^*, of 10^{-6} m^{-1} was used. This value is recommended and justified in draft NUREG-1720, *Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for License Termination* (NRC, 2002).

For the case of ore material on contaminated surfaces, equilibrium is assumed in the decay chains through Ra-226 and Ra-224. Rn-222 and Rn-220 are progeny are assumed to be present at 90% of their equilibrium values. Thorium-doping work areas are assumed to have the most unfavorable composition for gross radiation measurement that is possible: 42.4% equilibrium between Th-232 its progeny.

These assumptions lead to the DCGL values in Table 4-7.

Table 4-7. DCGL Values for Surface Contamination

	Isotope	Gross Alpha/Beta DCGL values
Ore Material or Presscake	U-238+chain	1862 dpm alpha/100 cm^2 1372 dpm beta/100 cm^2 245 dpm U-238/100 cm^2
	PbBiPo-210	2136 dpm alpha/100 cm^2 or 4272 dpm beta/100 cm^2 2136 dpm Pb-210/100 cm^2
	Th-232+chain	470 dpm alpha/100 cm^2 or 313 dpm beta/100 cm^2 82.5 dpm Th-232/100 cm^2
Thorium doping	Th-232+chain	288 dpm alpha/100 cm^2 157 dpm beta/100 cm^2 92 dpm Th-232/100 cm^2

Mixture DCGLs for surfaces contaminated by ore material or presscake solids are calculated as follows, assuming the activity ratios for soil contamination, 42% Th-232 and 58% U-238:

$$\text{Gross Alpha DCGL} = \frac{1}{\frac{0.42}{288} + \frac{0.58}{1862}} = 565 \frac{\text{dpm}}{100\ \text{cm}^2}$$

$$\text{Gross Beta DCGL} = \frac{1}{\frac{0.42}{157} + \frac{0.58}{1372}} = 323 \frac{\text{dpm}}{100\ \text{cm}^2}$$

These are the best estimates available and are provisional gross alpha and gross beta DCGL values for surface contamination. These values apply strictly for the purpose of establishing a cost estimate for decommissioning and are not intended as a basis for license termination. Prior to submitting a final decommissioning plan, the isotopic ratios for surface contamination should be determined from wipe sampling of representative surfaces.

5. COST ESTIMATE

The estimated cost for this project is $5,894,248 with the limitations and assumptions discussed previously. This estimate includes decontamination of equipment, concrete, and material (where feasible), radioactive waste disposal, radioactive waste volume reduction, health physics support, and final release survey. Details of the cost elements and methodologies are discussed below.

5.1 ESTIMATING APPROACH

This cost estimate is based on a detailed survey performed in 1993 by SEG (Reference 6.1), results of routine surveys performed at the site in the years since 1993, and supplemental measurements and laboratory analyses acquired in January 2003. This cost estimate reflects present day (2003) decommissioning standards and unit costs for labor, equipment rental, transportation, and disposal.

The Radiation Safety Officer at CSM indicated in 2002 that the licensed activities are continuing in essentially the same locations at the CSM facility as they were in 1993, with minor changes as noted in this report. In addition, no major spills or releases of radioactive materials have occurred since 1993. Therefore contamination levels in plant areas are considered to be unchanged from 1993. However, the depth of contamination in soils around the site is considered now to require excavation to a depth of 12 inches rather than the 6 inches used in the 1993 cost estimate.

The release criteria for standing structures and soil have changed from numerical concentrations to a dose-based standard of 25 mrem/y. This made it necessary for WESTON to modify certain assumptions that SEG made concerning the extent of contamination that would have to be removed from standing structures and soil. Those assumptions were that more extensive decontamination would be required for standing structures and additional contaminated soil would require off-site disposal.

5.1.1 Procedures used to estimate the areas requiring cleanup

Surface contamination estimates were based on physical dimensions for the CSM plant and information provided in the 1993 survey performed by the Scientific Ecology Group (SEG). The building surface contamination areas that required cleanup were updated to include new areas where licensed activities, such as thorium doping are taking place.

Soil contamination volumes requiring cleanup were based on the 1993 SEG decommissioning funding plan as well as a supplemental radiological characterization that was performed by WESTON in January 2003. The goals of the WESTON supplemental characterization were to define background, to better define depths of contamination, to characterize the extent of contamination around the bulk storage bins, and to provide data for the revised DCGL calculations.

Estimates of surface contamination in plant areas were similarly based on the 1993 SEG report and verified by a review of contamination data from routine surveys performed in the past several years by CSM.

Current labor rates, transportation fees, and disposal charges were applied to the activities, and volumes and quantities of materials associated with the decommissioning effort. Rates, fees, and charges came from three sources, as listed below.

- Current quotes or existing contract rates of transportations and disposal charges from the licensed disposal sites that are currently acceptable to CSM,
- Labor rates that would be quoted by Weston Solutions in a competitive bid for similar work, as taken from proposals completed in the past year, or
- Regional rates for construction labor and equipment rental quoted in industry references, such as "RS Means Labor Rates for Construction Industry, 2002" for the Reading. PA region.

5.2 ESTIMATING METHODOLOGY

WESTON developed tables that correlate closely with the guidance provided in NUREG 1757, Volume 3, Appendix A to provide the buildup to the total cost estimate. WESTON's cost estimate tables are provided in Appendix B. The rationale for the values in those tables is explained in the following sections. Unit costs and explanations are provided for each of the major categories of work that would need to be performed. Contracted labor and health physics personnel were assumed to provide support for all decommissioning activities. Time estimating factors, hours by labor category, labor rates, labor costs by major decommissioning task, equipment rental rates, and laboratory charges are provided in Tables 4, 8, 9, 10, 12, and 13 of Appendix B. Table 15 in Appendix B provides a summary roll-up and total of all costs.

5.2.1 Equipment and Tank Decontamination

In 1993 SEG assumed that equipment decontamination would generate a compacted waste volume equivalent to 5% of the volume of the equipment being decontaminated. That value is applied for the new cost estimate for the following reasons:

- The NRC accepted that volume reduction ratio for the CSM site in the last cost estimate and has not provided more stringent values.
- SEG had extensive experience with such activities and based their estimate on that experience. SEG continues to perform extensive decontamination and volume reduction activities at the Oak Ridge National Laboratory sites, and has continued to see these volume reduction rates under comparable ceircumstances.
- Methods for compacting structural materials and equipment have continued to improve since 1993 and would, if anything, make the assumed volume reduction ratio easier to attain than in 1993.
- The volume estimate for equipment and tank decontamination includes both protective clothing and cleaning materials, much of which will be monitored and found to meet free release limits.

The numbers and dimensions of facility components are provided in Table 1 of Appendix B. Unit labor factors for handling the equipment are provide in Table 4 of Appendix B.

5.2.2 Concrete and Surface Decontamination

Concrete processing costs were estimated from WESTON construction experience with scabbling and pressure washing concrete surfaces, which correlated well with SEG's decommissioning experience described in the 1993 cost estimate. The evaluation conducted by SEG in 1993 determined that surfaces could be decontaminated and there have been no changes in the process or structures that would change that condition. Surface contamination data indicate no significant increases in the surface contamination levels around the plant since 1993. In addition, building surfaces are constructed of smooth finished surfaces that are not corroded and do not allow material to penetrate or stick - they are easily cleaned using water spray. Concrete surfaces are commonly deconned via scabbling as assumed in this document, and contamination from dust such as is in the work areas does not penetrate to a depth greater than is removed by scabbling.

Labor costs and equipment rental rates are taken from WESTON proposal efforts developed in the past year for similar activities and from accepted construction pricing references such as "RS Means Labor Rates for Construction Industry, 2002" for the Reading, PA region. The percentage of the areas in the structures that will have to be decontaminated was increased beyond those previously defined by SEG to meet the current decommissioning criteria. Dimensions and calculations for the facility structures are provided in Table 2 of Appendix B.

5.2.3 Soil Decontamination and Determination of Volumes

Soil decontamination includes the removal of three categories of material: residual ores, presscake, and contaminated soils around the operations buildings. The volume of ores was taken as the average quantity of ore held on-site to ensure continued operations of the site. Realistically, the ore feedstock should not be included in the cost estimate for decontamination because it is a valuable commodity and common sense dictates that CSM would use up all ores on-site prior to terminating its license. In addition, if ores were left at the site when CSM ceased operating, the most likely approach would be to transfer them to another licensee who would be willing to pay for transportation, or to sell them to another licensed operator to regain the price that had been paid by CSM. However, this cost estimate included the volume of the on-site ore with the excavated soils and presscake for disposal as 11.e.2 material under contract rates that CSM has currently negotiated with a facility in Utah.

CSM conducted an extensive sampling and analysis program from December 2002 through January 2003. Soil samples were collected at six-inch depths to a maximum of two feet from locations indicated on the site drawing in Appendix A of this document. All sample locations were in exposed dirt areas. The volume of contaminated soil to be excavated was estimated by establishing contours around the process buildings based on the soil sample results and the DCGLs calculated in this document. Soils under the process building floors were assumed not to be contaminated. The presscake (fluoride residues that are disposed at the bulk storage bins) volumes were assumed to be the current amount of about 4,000 tons, which will diminish over the near future, as material is disposed at the Utah uranium mill site. Volumes of these materials are listed in Table 2 of Appendix B.

The costs for recontouring the site are shown in Table 10 of Appendix B, "Total Labor Costs By Major Decommissioning Task", under the heading "Restoration". Only regrading was considered and no backfilling will be required because of the limited area and depth of excavation. No gravel is needed and no seed was included.

5.2.4 Radioactive Waste Transportation and Disposal Cost

Contaminated piping, equipment, and objects that cannot be properly decontaminated or surveyed for surface contamination are assumed to be radioactive waste. These materials would be disposed of at a licensed disposal facility. Rates were acquired from WESTON proposals that had been completed since January 2001 for disposal of similar materials at Envirocare in Utah. The rate used in this estimate is $82 per cubic foot. The current (2003) fully loaded cost for disposal at WCS in Texas is $31 per cubic foot, but the higher value at Envirocare was used because contracted transportation rates were available for the Utah destination.

Pressacake, ores, and soils and concrete chips that exceeded release criteria would be transported to a licensed uranium mill in the western United States. Transportation costs and disposal fees associated with uranium recovery processing are current CSM contract rates of $640 per ton and $295 per ton, respectively. Packaging, shipping, and disposal costs are provided in Table 11 of Appendix B.

5.2.5 Radioactive Waste Volume Reduction Cost

Soil processing in the form of segregation will be applied to the soils and scabbling wastes because those materials are not homogeneously contaminated and are therefore readily addressed by this process. WESTON contacted a radiological services company that operates a segmented gate soil sorter to acquire current values for volume reduction rates and costs. The effectiveness of soil sorting will depend on how uniformly the radioactive material is distributed in the soil. Volume reduction factors have ranged from 0 to 99% at 15 project sites operated by the contractor, and the higher reduction rates were found under conditions that were similar to those at the CSM plant. For this estimate the volume reduction is assumed to be 95% because the contractor's recent experience supported that value and that correlates with the value used in the 1993 cost estimate that was previously accepted by the NRC.

The contractor estimated fully loaded costs at between $20 and $50 per cubic yard of soil processed, which correlated with the cost for that unit at a current WESTON pilot project in the midwest. The higher price was applicable if the contractor had to provide excavation, soil handling, and health and safety support on the project. Costs for excavation, handling and safety support are included in other parts of this cost estimate, so commercially available soil sorting services were estimated at a fully loaded cost of $ 20 per cubic yard of soil processed. Volume reduction for equipment and debris involve cutting and sizing the materials as they are removed from the facility. Those costs are included in the construction labor rates used in this estimate. Soil volume reduction costs are listed as a line item in table 15 of Appendix B.

5.2.6 Survey and Release

The costs for completing the final status surveys of the site were estimated using the measured areas of the excavations, floors, walls, and ceilings. Reasonable rates were established for performing each type of measurement, and current labor rates for several worker categories, including rad tech, decon tech, rad supervisor, and Certified Health Physicist were factored by the duration of each task. Hours and costs for Final Status Surveys are tallied as an individual line item. Final Decommissioning Plan development is included under the 200 hours of the CHP, 100 hours for the Rad Supervisor, and 100 hours for the Site Manager in the category of "Planning and Preparation" in Table 10. of Appendix B. Final status surveys, including the report preparation costs are included in that Table under the "Final Status Surveys" heading.

5.2.7 Health Physics Support Cost

Labor rates for construction workers and health physics staff are provided in Table 9 of Appendix B. The time required for a Radiological Technician to conduct final release surveys is itemized in Table 7 of Appendix B, and the time required for support from a Radiological Supervisor and Site Manager is factored at one-third of the technician's time. A Certified Health Physicist is included as a lump sum of 300 hours to support the planning and final status survey data evaluation.

5.2.8 Taxes and Contingency

Tax is estimated at the 6% Pennsylvania state gross receipts rate. According to WESTON financial managers, state taxes are applicable only to the activities that are completed within the state. A 15% contingency is applied to the full subtotal cost. This is less than the standard value (25%) used by the U. S. Nuclear Regulatory Commission, but is justified by the following conditions:

- The approach to estimating costs is generally as would be performed by a contractor developing a construction bid. All labor is assumed to be performed by private contractors at rates that include at least a 10% profit margin.
- The estimate is detailed and conservative in many of its assumptions, thereby limiting the potential for omitting relevant expenses.
- The conditions at the site are well known, the site has no periods of unknown or uncontrolled operations, and the site owners/operators have generally complied with regulatory requirements.
- The quantities of licensed radioactive materials and the site areas where they are handled are small compared with many industrial operations such as uranium mills. This limits the potential for significant costs to be overlooked.

This estimate is for budgetary purposes only and is not a proposal or cost estimate for WESTON to perform work. Cleanup limits developed for this document are intended for cost estimating purposes only and are not intended for use as license termination criteria.

5.3 THE TOTAL COST OF DECOMMISSIONING THE BOYERTOWN SITE

The grand total estimated for decommissioning is $5,894,248. In general, the increase in decommissioning costs resulted from the restrictive cleanup levels that are implied by the current dose-based license termination standard, inflation related increases in labor and equipment rates and disposal fees, and the addition of costs to handle the presscake. These increased costs were offset to a degree by locating facilities that will accept contaminated soil as feed material or as solid waste for land disposal. The 2003 decommissioning cost estimate represents a 49% increase over the SEG decommissioning cost estimate given in Reference 6.1.

6. REFERENCES

Scientific Ecology Group, Inc. (SEG), Decommissioning Cost Estimate for Boyertown, Pennsylvania Site, 1993.

NRC, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, 1984.

NRC, Consolidated NMSS Decommissioning Guidance: Decommissioning Process, Draft NUREG-1757, Volume 1, 2002.

NRC, Residual Radioactive Contamination From Decommissioning, User's Manual DandD Version 2.1, NUREG/CR-5512, Vol. 2, 2001.

EPA 1998. Exposure Factors Handbook, Volume 2, PB98-124233, Chapter 13. Washington, DC.

K McFadden, et al. 2001. Residual Radioactive Contamination From Decommissioning: User's Manual DandD Version 2.1. NUREG/CR-5512, Vol. 2, SAND2001-0822P. Sandia National Laboratories, Albuquerque, NM.

NCRP 1999. Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies. NCRP Report No. 129. National Council on Radiation Protection and Measurements, Bethesda, MD, Page 104.

NRC 2002. Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for License Termination, Draft NUREG-1720, Nuclear Regulatory Commission.

Weston Solutions 2003. Dose Assessment for Recycling of Wastewater Treatment Sludge from the Cabot Supermetals Facility in Boyertown, Pennsylvania. Submittal to NRC, Weston Solutions.

Attachment A: Degree of Equilibrium in Ore Material and Presscake solids

This attachment provides isotopic ratio data for the general area of the site. This section does not address the wastewater treatment plant. Uranium, thorium and lead-210 values were based on chemical separation and analysis. Lead-212, actinium-228 and lead 214 were based gamma spectroscopy. Review of the data leads to the following impressions:

- U-238 and U-234 are approximately in equilibrium (Figure A-1),
- The ore material and the presscake solids are difficult materials to dissolve, leading to systematically low concentration estimates of uranium, thorium, and lead-210 (Figures A-2, A-3, A-6),
- Since equilibrium is present within the analyte pairs Th-228 - Th-232 (Figure A-5) and Ac-228 – Pb-212 (Figure A-7), the entire Th-232 decay chain appears to be in equilibrium.
- It would be conservative to assume that the uranium decay chain is in equilibrium for the purposes of deriving soil DCGL values.
- The average activity percent in soil is 58% U-238: 42% Th-232 (Figure A-4).

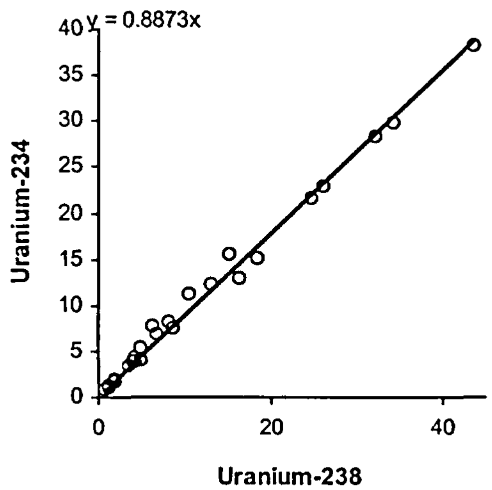


Figure A-1. U-238/U-234 Ratio

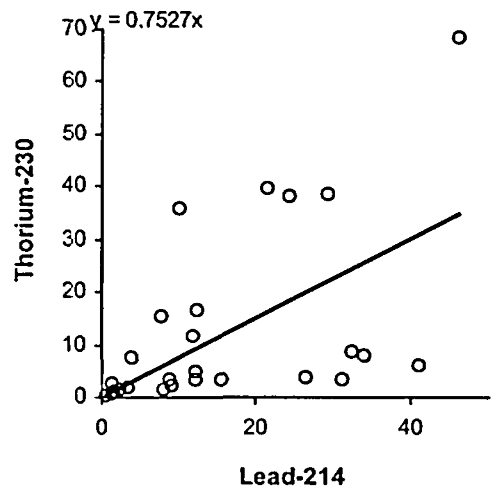


Figure A-2. Pb-214/Th-230 Ratio

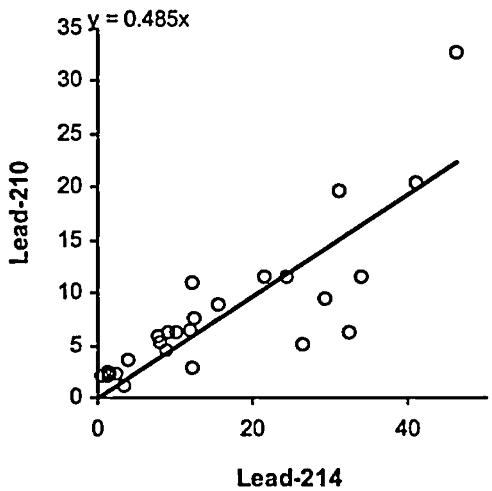


Figure A-3. Pb-214/Pb-210 Ratio

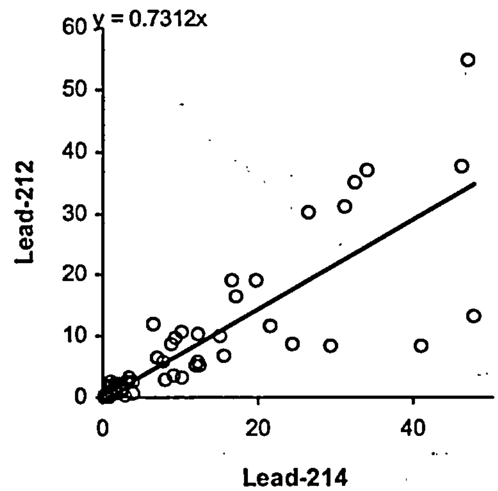


Figure A-4. Pb-214/Pb212 Ratio

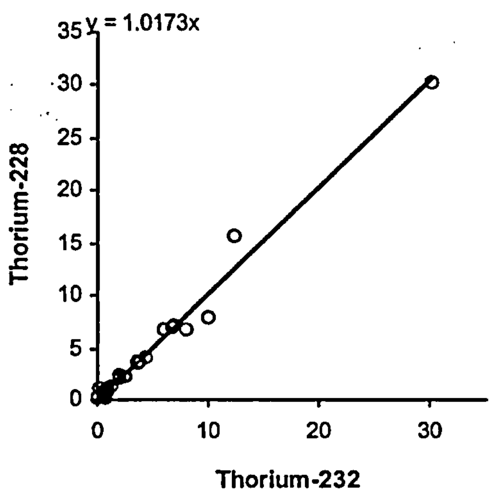


Figure A-5. Th-232/Th-228 Ratio

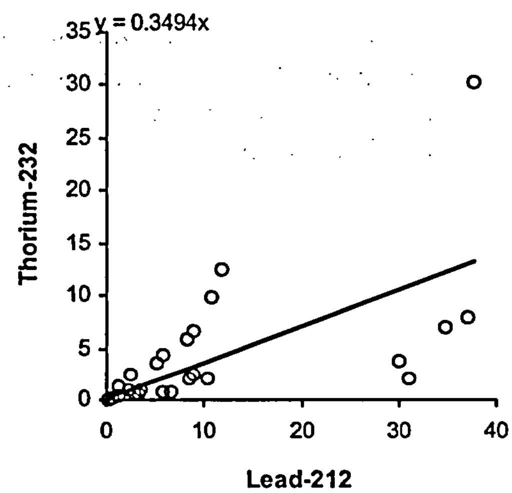


Figure A-6. Pb-212/Th-232 Ratio

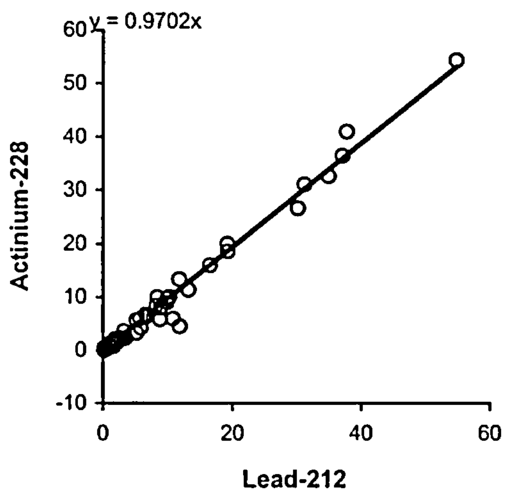


Figure A-7. Pb-212/Ac-228 Ratio

Based on Figures A-1 through A-7, it is apparent that areas affected by either presscake solids or ore material are in decay equilibrium. Cleanup can be verified by gamma spectroscopy using the analytes Pb-212 or Ac-228 as surrogates for the Th-232 chain and Pb-214 as a surrogate for the U-238 decay chain. Direct gamma measurements can guide routine excavation.

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 6/14/2003 4:19:44 PM
Site Name: Cabot Boyertown -Suburban resident -U238 + chain
Description: Cabot Boyertown -- Suburban resident +U-238+chain
FileName:C:\DandD_Docs\UraniumResidential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentrations for each radionuclide		Value 1.40E+01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01

		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)

		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)

Vegetables		
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve DandD's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)	Value	Probability
	2.20E-04	0.00E+00
	2.30E-03	5.00E-02
	3.20E-03	1.00E-01
	3.90E-03	1.50E-01
	4.70E-03	2.00E-01
	6.20E-03	3.00E-01
	7.90E-03	4.00E-01
	9.90E-03	5.00E-01
	1.20E-02	6.00E-01
	1.60E-02	7.00E-01
	2.10E-02	8.00E-01
	2.50E-02	8.50E-01
	3.10E-02	9.00E-01
	4.20E-02	9.50E-01
	3.90E-01	1.00E+00
	Default CONSTANT(none)	

		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)

Justification for modification: See the explanation for MLV(1)	Value / Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01

		3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01

	3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
	Default CONSTANT(none)
	Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% of the 113 calculated TEDE values are < 1.04E+01 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 8.64E+00 to 1.28E+01 mrem/year

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 6/9/2003 11:06:06 AM
Site Name: Cabot Boyertown -Suburban resident -Pb-210
Description: Cabot Boyertown -- Suburban resident Pb-210 + Po-210
FileName:C:\DandD_Docs\Pb210-Residential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
210Pb	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL value		Value 1.00E+00
210Bi	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calculation		Value 1.00E+00

concentration for DCGL calculation		
210Po	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calculation		Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)

		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 3.98E+01

Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00

suburban activity		
		<u>Default</u> CONSTANT(kg/y)
		<u>Value</u> 2.06E+01
MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)
<u>Justification for modification:</u> This distribution is obtained when one uses Crystal Ball to convolve DandD's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		<u>Value</u> <u>Probability</u> 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01

		2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01

		1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01

	7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
	Default CONSTANT(none)
	Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% of the 113 calculated TEDE values are < 3.81E+00 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 3.24E+00 **to** 5.04E+00 **mrem/year**

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 6/14/2003 4:43:36 PM
Site Name: Building Occupancy
Description: Radium226+ Chain Building Occupancy
FileName:C:\DandD_Docs\Ra-6-BO-6-10-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
226Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00
222Rn	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Po	UNLIMITED	CONSTANT(dpm/100 cm**2)

Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: presumed degree of equilibrium		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 1.58E-02 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 1.58E-02 to 1.58E-02 mrem/year

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 6/14/2003 5:04:29 PM
Site Name: Building Occupancy
Description: Ra-228+chain, ore material Building Occupancy,
FileName:C:\DandD_Docs\Ra-228+chain-BO-OreMaterial.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
228Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ac	UNLIMITED	CONSTANT(dpm/100 cm**2)

Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
224Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 1.00E+00
212Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
212Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed equilibrium value		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 5.70E-02 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 5.70E-02 to 5.70E-02 mrem/year

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 6/9/2003 10:56:20 AM
Site Name: Cabot Boyertown -Suburban resident -Radium-226
Description: Cabot Boyertown -- Suburban resident
FileName:C:\DandD_Docs\Radium226Residential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
226Ra	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL		Value 1.00E+00
222Rn	UNLIMITED	CONSTANT(pCi/g)

Justification for concentration: unit concentration for DCGL	Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)

Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00

		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01

MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)

Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve DandD's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)	<table><tr><th>Value</th><th>Probability</th></tr><tr><td>2.20E-04</td><td>0.00E+00</td></tr><tr><td>2.30E-03</td><td>5.00E-02</td></tr><tr><td>3.20E-03</td><td>1.00E-01</td></tr><tr><td>3.90E-03</td><td>1.50E-01</td></tr><tr><td>4.70E-03</td><td>2.00E-01</td></tr><tr><td>6.20E-03</td><td>3.00E-01</td></tr><tr><td>7.90E-03</td><td>4.00E-01</td></tr><tr><td>9.90E-03</td><td>5.00E-01</td></tr><tr><td>1.20E-02</td><td>6.00E-01</td></tr><tr><td>1.60E-02</td><td>7.00E-01</td></tr><tr><td>2.10E-02</td><td>8.00E-01</td></tr><tr><td>2.50E-02</td><td>8.50E-01</td></tr><tr><td>3.10E-02</td><td>9.00E-01</td></tr><tr><td>4.20E-02</td><td>9.50E-01</td></tr><tr><td>3.90E-01</td><td>1.00E+00</td></tr></table>

		Default CONSTANT(none)
		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01 3.90E-03 / 1.50E-01 4.70E-03 / 2.00E-01 6.20E-03 / 3.00E-01 7.90E-03 / 4.00E-01 9.90E-03 / 5.00E-01 1.20E-02 / 6.00E-01 1.60E-02 / 7.00E-01 2.10E-02 / 8.00E-01 2.50E-02 / 8.50E-01 3.10E-02 / 9.00E-01

		4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01

	2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
	Default CONSTANT(none)
	Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% of the 113 calculated TEDE values are < 7.58E+00 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 6.84E+00 to 8.78E+00 mrem/year

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 6/9/2003 11:18:05 AM
Site Name: Cabot Boyertown -Suburban resident -Ra228 ch
Description: Cabot Boyertown -- Suburban resident Ra-228 +Th-228 chain
FileName:C:\DandD_Docs\Radium8Residential6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
228Ra	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentration for DCGL calcualtion		Value 1.00E+00
228Th+C	UNLIMITED	CONSTANT(pCi/g)

Justification for concentration: Unit concentration for DCGL calculation	Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)

Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00

		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01

MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)

Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve DandD's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)	Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01 3.90E-03 / 1.50E-01 4.70E-03 / 2.00E-01 6.20E-03 / 3.00E-01 7.90E-03 / 4.00E-01 9.90E-03 / 5.00E-01 1.20E-02 / 6.00E-01 1.60E-02 / 7.00E-01 2.10E-02 / 8.00E-01 2.50E-02 / 8.50E-01 3.10E-02 / 9.00E-01 4.20E-02 / 9.50E-01 3.90E-01 / 1.00E+00

Value	Probability
2.20E-04	0.00E+00
2.30E-03	5.00E-02
3.20E-03	1.00E-01
3.90E-03	1.50E-01
4.70E-03	2.00E-01
6.20E-03	3.00E-01
7.90E-03	4.00E-01
9.90E-03	5.00E-01
1.20E-02	6.00E-01
1.60E-02	7.00E-01
2.10E-02	8.00E-01
2.50E-02	8.50E-01
3.10E-02	9.00E-01
4.20E-02	9.50E-01
3.90E-01	1.00E+00

		Default CONSTANT(none)
		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01 3.90E-03 / 1.50E-01 4.70E-03 / 2.00E-01 6.20E-03 / 3.00E-01 7.90E-03 / 4.00E-01 9.90E-03 / 5.00E-01 1.20E-02 / 6.00E-01 1.60E-02 / 7.00E-01 2.10E-02 / 8.00E-01 2.50E-02 / 8.50E-01 3.10E-02 / 9.00E-01

		4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01

	2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
	Default CONSTANT(none)
	Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% of the 113 calculated TEDE values are < 7.19E+00 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 6.92E+00 to 7.61E+00 mrem/year

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 6/18/2003 5:32:53 PM
Site Name: CSM-Suburban resident -58%U238-42%TH232
Description: Cabot Boyertown -- Suburban resident
FileName:C:\DandD_Docs\rESIDENTIAL-58u-42TH-6-19-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: 0.58 pCi/g for each nuclide in chain		Value 8.12E+00
232Th+C	UNLIMITED	CONSTANT(pCi/g)

Justification for concentration: 0.42 pCi/g of each nuclide in chain	Value 4.20E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)

Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01
		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00

		Default CONSTANT(kg/y)
		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01

MLV(1):Mass-Loading : Leafy Vegetables	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)

Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve DandD's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)	

Value	Probability
2.20E-04	0.00E+00
2.30E-03	5.00E-02
3.20E-03	1.00E-01
3.90E-03	1.50E-01
4.70E-03	2.00E-01
6.20E-03	3.00E-01
7.90E-03	4.00E-01
9.90E-03	5.00E-01
1.20E-02	6.00E-01
1.60E-02	7.00E-01
2.10E-02	8.00E-01
2.50E-02	8.50E-01
3.10E-02	9.00E-01
4.20E-02	9.50E-01
3.90E-01	1.00E+00

		Default CONSTANT(none)
		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01 3.90E-03 / 1.50E-01 4.70E-03 / 2.00E-01 6.20E-03 / 3.00E-01 7.90E-03 / 4.00E-01 9.90E-03 / 5.00E-01 1.20E-02 / 6.00E-01 1.60E-02 / 7.00E-01 2.10E-02 / 8.00E-01 2.50E-02 / 8.50E-01 3.10E-02 / 9.00E-01

		4.20E-02 9.50E-01 3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01

	2.50E-02 8.50E-01 3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
	Default CONSTANT(none)
	Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% of the 113 calculated TEDE values are < 9.33E+00 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 8.29E+00 to 1.10E+01 mrem/year

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 6/14/2003 4:50:34 PM
Site Name: Building Occupancy
Description: Thorium+chain, ore material Building Occupancy,
FileName:C:\DandD_Docs\Th-232+chain-OreMaterial.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentrations		Value 1.00E+00
228Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)

Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
228Ac	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Expected degree of equilibrium		Value 1.00E+00
224Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 1.00E+00
212Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
212Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed equilibrium value		Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * FI	CONSTANT(1/m)

Justification for modification: NUREG-1720	Value 1.00E-06
	Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 3.03E-01 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 3.03E-01 to 3.03E-01 mrem/year

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 6/14/2003 4:53:28 PM
Site Name: Building Occupancy
Description: Thorium doping Building Occupancy, worst case equilibrium assumption
FileName:C:\DandD_Docs\Th-232+chain-doping.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentrations		Value 1.00E+00
228Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium assumption		Value 4.24E-01
228Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)

Justification for concentration: Worst case equilibrium value		Value 4.24E-01
228Ac	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01
224Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01
212Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: worst case equilibrium value		Value 4.24E-01
212Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Worst case equilibrium value		Value 4.24E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	CONSTANT(1/m)

Justification for modification: NUREG-1720	Value 1.00E-06
	Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 2.70E-01 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 2.70E-01 to 2.70E-01 mrem/year

DandD Residential Scenario

DandD Version: 2.1.0
Run Date/Time: 6/9/2003 11:10:56 AM
Site Name: Cabot Boyertown -Suburban resident -Th232 ch
Description: Cabot Boyertown -- Suburban resident Th232 chain
FileName:C:\DandD_Docs\Thorium232Residential-6-9-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 113
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON
Agricultural Pathway is ON
Drinking Water Pathway is ON
Irrigation Pathway is ON
Surface Water Pathway is OFF

Justification for Pathway Selection: Aquaculture is not a suburban activity.

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
232Th+C	UNLIMITED	CONSTANT(pCi/g)
Justification for concentration: Unit concentrations for derivation of DCGL		Value 1.00E+00

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
Uv(1):Diet - Leafy	Yearly human consumption of leafy vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on EPA Exposure Factors Handbook Table 13-33.		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 2.14E+01
Uv(2):Diet - Roots	Yearly human consumption of other vegetables	CONSTANT(kg/y)
Justification for modification: 50% of average homegrown vegetable intake for Northeast based on Exposure Factors Handbook Table 13.33 (This also includes cereal grains)		Value 1.70E+01
		Default CONSTANT(kg/y)
		Value 4.46E+01
Uv(3):Diet - Fruit	Yearly human consumption of fruits	CONSTANT(kg/y)
Justification for modification: Average homegrown fruit intake for northeast resident based on Exposure Factors Handbook table 13-33.		Value 1.90E+01

		Default CONSTANT(kg/y)
		Value 5.28E+01
Uv(4):Diet - Grain	Yearly human consumption of grains	CONSTANT(kg/y)
Justification for modification: We have pooled grain intake with root intake in this simulation. The EPA Exposure Factors Handbook does not distinguish between grains and vegetables in Table 13-33.		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.44E+01
Ua(1):Diet - Beef	Yearly human consumption of beef	CONSTANT(kg/y)
Justification for modification: Raising cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 3.98E+01
Ua(2):Diet - Poultry	Yearly human consumption of poultry	CONSTANT(kg/y)
Justification for modification: Raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)

		Value 2.53E+01
Ua(3):Diet - Milk	Yearly human consumption of milk	CONSTANT(L/y)
Justification for modification: Rasing dairy cattle is not a suburban activity		Value 0.00E+00
		Default CONSTANT(L/y)
		Value 2.33E+02
Ua(4):Diet - Egg	Yearly human consumption of eggs	CONSTANT(kg/y)
Justification for modification: raising poultry is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 1.91E+01
Uf:Diet - Fish	Yearly human consumption of fish produced from an onsite pond	CONSTANT(kg/y)
Justification for modification: Aquaculture is not a suburban activity		Value 0.00E+00
		Default CONSTANT(kg/y)
		Value 2.06E+01
MLV(1):Mass-Loading : Leafy	Mass-loading factor for leafy vegetables	CONTINUOUS LINEAR(none)

Vegetables		
Justification for modification: This distribution is obtained when one uses Crystal Ball to convolve DandD's dry to weight distribution for fruit with the distribution for soil adhesion to fresh suburban garden products found on page 104 of NCRP 129 (i.e. GM= 0.001, GSD=2.2)		Value / Probability 2.20E-04 / 0.00E+00 2.30E-03 / 5.00E-02 3.20E-03 / 1.00E-01 3.90E-03 / 1.50E-01 4.70E-03 / 2.00E-01 6.20E-03 / 3.00E-01 7.90E-03 / 4.00E-01 9.90E-03 / 5.00E-01 1.20E-02 / 6.00E-01 1.60E-02 / 7.00E-01 2.10E-02 / 8.00E-01 2.50E-02 / 8.50E-01 3.10E-02 / 9.00E-01 4.20E-02 / 9.50E-01 3.90E-01 / 1.00E+00
		Default CONSTANT(none)

Value	Probability
2.20E-04	0.00E+00
2.30E-03	5.00E-02
3.20E-03	1.00E-01
3.90E-03	1.50E-01
4.70E-03	2.00E-01
6.20E-03	3.00E-01
7.90E-03	4.00E-01
9.90E-03	5.00E-01
1.20E-02	6.00E-01
1.60E-02	7.00E-01
2.10E-02	8.00E-01
2.50E-02	8.50E-01
3.10E-02	9.00E-01
4.20E-02	9.50E-01
3.90E-01	1.00E+00

		Value 1.00E-01
MLV(2):Mass-Loading : Other Vegetables	Mass-loading factor for other vegetables	CONTINUOUS LINEAR(none)

Justification for modification: See the explanation for MLV(1)	

Value	Probability
2.20E-04	0.00E+00
2.30E-03	5.00E-02
3.20E-03	1.00E-01
3.90E-03	1.50E-01
4.70E-03	2.00E-01
6.20E-03	3.00E-01
7.90E-03	4.00E-01
9.90E-03	5.00E-01
1.20E-02	6.00E-01
1.60E-02	7.00E-01
2.10E-02	8.00E-01
2.50E-02	8.50E-01
3.10E-02	9.00E-01
4.20E-02	9.50E-01

		3.90E-01 1.00E+00
		Default CONSTANT(none)
		Value 1.00E-01
MLV(3):Mass-Loading : Fruits	Mass-loading factor for fruits	CONTINUOUS LINEAR(none)
Justification for modification: See the explanation for MLV(1)		Value Probability 2.20E-04 0.00E+00 2.30E-03 5.00E-02 3.20E-03 1.00E-01 3.90E-03 1.50E-01 4.70E-03 2.00E-01 6.20E-03 3.00E-01 7.90E-03 4.00E-01 9.90E-03 5.00E-01 1.20E-02 6.00E-01 1.60E-02 7.00E-01 2.10E-02 8.00E-01 2.50E-02 8.50E-01 3.10E-02 9.00E-01

	3.10E-02 9.00E-01 4.20E-02 9.50E-01 3.90E-01 1.00E+00
	Default CONSTANT(none)
	Value 1.00E-01

Element Dependant Parameters

None

Correlation Coefficients:

None

Summary Results:

90.00% of the 113 calculated TEDE values are < 8.55E+00 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 7.88E+00 to 9.44E+00 mrem/year

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 6/13/2003 11:17:13 AM
Site Name: Building Occupancy
Description: Uranium Chain Building Occupancy
FileName:C:\DandD_Docs\U-BO-6-10-03.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are distributed among all progeny
Number of simulations: 100
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
238U	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit Concentration		Value 1.00E+00
234Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit Concentration		Value 1.00E+00
234Pa	UNLIMITED	CONSTANT(dpm/100 cm**2)

Justification for concentration: Unit concentration		Value 1.00E+00
234U	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit Concentration		Value 1.00E+00
230Th	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00
226Ra	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Unit concentration		Value 1.00E+00
222Rn	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Po	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Bi	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Presumed degree of equilibrium		Value 9.00E-01
210Pb	UNLIMITED	CONSTANT(dpm/100 cm**2)

Justification for concentration: presumed degree of equilibrium	Value 9.00E-01

Site Specific Parameters:

General Parameters:

Parameter Name	Description	Distribution
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * FI	CONSTANT(1/m)
Justification for modification: NUREG-1720		Value 1.00E-06
		Default DERIVED(1/m)

Correlation Coefficients:

None

Summary Results:

90.00% of the 100 calculated TEDE values are < 1.02E-01 mrem/year .
The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 1.02E-01 to 1.02E-01 mrem/year.

Attachment C: Net Exposure Rate and Deep Dose Equivalent Rate DCGL

DCGL values in terms of net exposure rate and isotropic deep dose equivalent rate are derived in this section. These values are for use with air equivalent and tissue equivalent detectors respectively. All calculations are based on ANSI/ANS-6.6.1-1987 soil.

Figure C-1. Microshield 6.0 report providing the net exposure rate for an infinite slab of soil, 30 cm thick, having a density 1.6, and 1 mixture DCGL consisting of 58% U-238 activity and 42% Th-232 in equilibrium with progeny.

MicroShield v6.00 (6.0-00066)
AQ_Safety,_Inc.

Page	:1		
DOS File	:CABOT-GENERAL AREA-58U-42TH.ms6	**File Ref**	:
		Date	:
Run Date	: June 19, 2003	**By**	:
Run Time	: 5:54:16 AM	**Checked**	:
Duration	: 00:00:00		

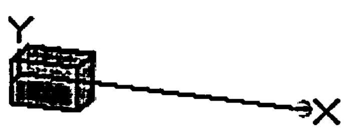
Case Title: Net U and Th
Description: EXTERNAL GAMMA DCGL ASSUMING 58% U- 42% TH
Geometry: 16 - Infinite Slab

Source Dimensions:

Thickness	30.0 cm	(11.8 in)

Dose Points

A	**X**	**Y**	**Z**
# 1	130 cm	0 cm	0 cm
	4 ft 3.2 in	0.0 in	0.0 in



Shields

Shield N	**Dimension**	**Material**	**Density**
Source	Infinite	ANS6.6.1-1987-soil	1.6
Air Gap		Air	0.00122

Source Input : Grouping Method - Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	μCi/cm³	Bq/cm³
Ac-228	1.8004e-006	6.6615e-002
Bi-210	2.4795e-006	9.1742e-002
Bi-212	1.8004e-006	6.6613e-002
Bi-214	2.4795e-006	9.1742e-002
Pb-210	2.4795e-006	9.1742e-002
Pb-212	1.8004e-006	6.6615e-002
Pb-214	2.4795e-006	9.1742e-002
Po-210	2.0305e-014	7.5127e-010
Po-212	1.1535e-006	4.2679e-002
Po-214	2.4790e-006	9.1722e-002
Po-216	1.8009e-006	6.6634e-002
Po-218	2.4800e-006	9.1760e-002
Ra-224	1.8009e-006	6.6634e-002
Ra-226	2.4800e-006	9.1760e-002
Ra-228	1.8004e-006	6.6615e-002
Rn-220	1.8009e-006	6.6634e-002
Rn-222	2.4800e-006	9.1760e-002
Th-228	1.8004e-006	6.6614e-002
Tl-208	6.4687e-007	2.3934e-002

Buildup : The material reference is - Source Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr/sec No Buildup	Exposure Rate mR/hr/sec With Buildup
0.015	8.476e-02	3.775e-05	1.176e-04	3.238e-06	1.009e-05
0.04	6.811e-04	1.658e-05	9.269e-04	7.335e-08	4.099e-06
0.05	4.730e-03	2.171e-04	1.715e-02	5.783e-07	4.569e-05
0.06	3.340e-04	2.363e-05	2.174e-03	4.694e-08	4.317e-06
0.08	4.990e-02	6.156e-03	5.220e-01	9.741e-06	8.260e-04
0.1	4.851e-03	8.584e-04	6.901e-02	1.313e-06	1.056e-04
0.15	2.772e-03	8.799e-04	4.198e-02	1.449e-06	6.913e-05
0.2	4.607e-02	2.175e-02	8.112e-01	3.840e-05	1.432e-03
0.3	3.630e-02	3.003e-02	7.168e-01	5.697e-05	1.360e-03
0.4	3.668e-02	4.549e-02	6.846e-01	8.864e-05	1.334e-03
0.5	1.088e-02	1.855e-02	2.028e-01	3.640e-05	3.981e-04
0.6	6.541e-02	1.450e-01	1.206e+00	2.831e-04	2.354e-03
0.8	2.989e-02	1.009e-01	5.815e-01	1.918e-04	1.106e-03
1.0	6.751e-02	3.168e-01	1.310e+00	5.840e-04	2.414e-03
1.5	2.640e-02	2.272e-01	6.583e-01	3.823e-04	1.108e-03
2.0	2.475e-02	3.270e-01	7.506e-01	5.056e-04	1.161e-03
3.0	2.389e-02	5.708e-01	1.029e+00	7.744e-04	1.396e-03
Totals	**5.158e-01**	**1.812e+00**	**8.604e+00**	**2.958e-03**	**1.513e-02**

A net exposure rate of 15.1 µR/hour corresponds to a net isotropic deep dose equivalent rate of 11.3 µRem/hour, according to the Microshield 6 Dose Equivalent Report.

Figure C-2. Microshield 6.0 report providing the net exposure rate for an infinite slab of soil, 30 cm thick, having a density 1.6, and 1 DCGL consisting of the U-238 chain in equilibrium with progeny.

MicroShield v6.00 (6.0-00066)
AQ_Safety,_Inc.

Page	:1	**File Ref**	:
DOS File	:CABOT-GENERAL AREA-100%U.ms6	**Date**	:
Run Date	: June 19, 2003	**By**	:
Run Time	: 4:54:59 AM	**Checked**	:
Duration	: 00:00:00		

Case Title: Net U
Description: EXTERNAL GAMMA DCGL ASSUMING 100% U
Geometry: 16 - Infinite Slab

Source Dimensions:

Thickness	30.0 cm	(11.8 in)

Dose Points

A	X	Y	Z
# 1	130 cm	0 cm	0 cm
	4 ft 3.2 in	0.0 in	0.0 in

Shields

Shield N	Dimension	Material	Density
Source	Infinite	ANS6.6.1-1987-soil	1.6
Air Gap		Air	0.00122

Source Input : Grouping Method - Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	µCi/cm³	Bq/cm³
Bi-210	1.9417e-011	7.1844e-007
Bi-214	3.8072e-006	1.4087e-001
Pb-210	3.0832e-010	1.1408e-005
Pb-214	3.8072e-006	1.4087e-001
Po-210	3.1178e-014	1.1536e-009
Po-214	3.8064e-006	1.4084e-001
Po-218	3.8080e-006	1.4090e-001

Ra-226	3.8080e-006	1.4090e-001
Rn-222	3.8080e-006	1.4090e-001

Buildup : The material reference is - Source
Integration Parameters

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.089e-02	9.305e-06	2.899e-05	7.981e-07	2.487e-06
0.05	1.558e-03	7.150e-05	5.648e-03	1.905e-07	1.505e-05
0.08	3.248e-02	4.006e-03	3.397e-01	6.340e-06	5.376e-04
0.1	1.912e-04	3.384e-05	2.720e-03	5.177e-08	4.162e-06
0.2	1.517e-02	7.166e-03	2.672e-01	1.265e-05	4.716e-04
0.3	2.907e-02	2.405e-02	5.740e-01	4.562e-05	1.089e-03
0.4	5.390e-02	6.685e-02	1.006e+00	1.303e-04	1.960e-03
0.5	2.516e-03	4.290e-03	4.691e-02	8.421e-06	9.209e-05
0.6	6.792e-02	1.506e-01	1.252e+00	2.939e-04	2.444e-03
0.8	1.331e-02	4.491e-02	2.589e-01	8.542e-05	4.925e-04
1.0	4.411e-02	2.070e-01	8.555e-01	3.815e-04	1.577e-03
1.5	2.682e-02	2.308e-01	6.687e-01	3.883e-04	1.125e-03
2.0	3.770e-02	4.980e-01	1.143e+00	7.700e-04	1.768e-03
Totals	**3.456e-01**	**1.238e+00**	**6.421e+00**	**2.124e-03**	**1.158e-02**

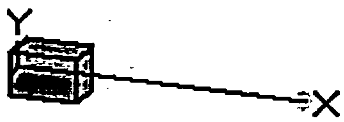
A net exposure rate of 11.6 μR/hour corresponds to a net isotropic deep dose equivalent rate of 8.6 μRem/hour, according to the Microshield 6 Dose Equivalent Report.

Figure C-3. Microshield 6.0 report providing the net exposure rate for an infinite slab of soil, 30 cm thick, having a density 1.6, and 1 DCGL consisting of the Th-232 chain in equilibrium with progeny.

MicroShield v6.00 (6.0-00066)
AQ_Safety,_Inc.

:	:1		
File	:CABOT-GENERAL AREA-100%Th.ms6	**File Ref**	:
		Date	:
Date	: June 19, 2003	**By**	:
Time	: 5:11:47 AM	**Checked**	:
ition	: 00:00:00		

Case Title: Net Th
Description: EXTERNAL GAMMA DCGL ASSUMING 100% Th
Geometry: 16 - Infinite Slab



Source Dimensions:

Thickness	30.0 cm	(11.8 in)

Dose Points

A	**X**	**Y**	**Z**
# 1	130 cm	0 cm	0 cm
	4 ft 3.2 in	0.0 in	0.0 in

Shields

Shield N	**Dimension**	**Material**	**Density**
Source	Infinite	ANS6.6.1-1987-soil	1.6
Air Gap		Air	0.00122

Source Input : Grouping Method - Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	**μCi/cm³**	**Bq/cm³**
Ac-228	4.7040e-006	1.7405e-001
Bi-212	4.7040e-006	1.7405e-001
Pb-212	4.7040e-006	1.7405e-001
Po-212	3.0128e-006	1.1147e-001
Po-216	4.7040e-006	1.7405e-001
Ra-224	4.7040e-006	1.7405e-001
Ra-228	4.7040e-006	1.7405e-001
Rn-220	4.7040e-006	1.7405e-001
Th-228	4.7040e-006	1.7405e-001
Tl-208	1.6896e-006	6.2514e-002

Buildup : The material reference is - Source
Integration Parameters

Results

Energy MeV	**Activity Photons/sec**	**Fluence Rate MeV/cm²/sec No Buildup**	**Fluence Rate MeV/cm²/sec With Buildup**	**Exposure Rate mR/hr/sec No Buildup**	**Exposure Rate mR/hr/sec With Buildup**
0.015	1.276e-01	5.684e-05	1.771e-04	4.875e-06	1.519e-05
0.04	1.780e-03	4.333e-05	2.422e-03	1.916e-07	1.071e-05
0.06	8.726e-04	6.174e-05	5.679e-03	1.226e-07	1.128e-05
0.08	7.511e-02	9.266e-03	7.857e-01	1.466e-05	1.243e-03
0.1	1.235e-02	2.185e-03	1.757e-01	3.343e-06	2.688e-04
0.15	7.242e-03	2.299e-03	1.097e-01	3.786e-06	1.806e-04

0.2	9.454e-02	4.464e-02	1.665e+00	7.880e-05	2.938e-03
0.3	4.538e-02	3.754e-02	8.960e-01	7.121e-05	1.700e-03
0.4	4.118e-03	5.107e-03	7.686e-02	9.951e-06	1.497e-04
0.5	2.414e-02	4.115e-02	4.500e-01	8.077e-05	8.833e-04
0.6	5.532e-02	1.226e-01	1.020e+00	2.394e-04	1.991e-03
0.8	5.545e-02	1.871e-01	1.079e+00	3.558e-04	2.052e-03
1.0	1.013e-01	4.756e-01	1.966e+00	8.766e-04	3.624e-03
1.5	2.335e-02	2.009e-01	5.821e-01	3.380e-04	9.794e-04
2.0	5.282e-04	6.977e-03	1.602e-02	1.079e-05	2.477e-05
3.0	6.239e-02	1.491e+00	2.687e+00	2.023e-03	3.645e-03
Totals	**6.915e-01**	**2.626e+00**	**1.152e+01**	**4.111e-03**	**1.972e-02**

A net exposure rate of 19.7 μR/hour corresponds to a net isotropic deep dose equivalent rate of 14.8 μRem/hour, according to the Microshield 6 Dose Equivalent Report.

ALARA Analyses

NUREG-1757, Volume 2, Appendix N gives guidance to NRC licensees on how to do "as low as reasonably achievable" (ALARA) analyses. This addendum to the CSM Decommissioning Funding Plan addresses the NRC's ALARA requirements for termination of the source materials license under which the CSM Boyertown plant operates. This analysis follows guidance in the above referenced document, and uses the appropriate default parameters from the guidance document and site-specific information taken from the Decommissioning Funding Plan (DFP) Cost Estimate.

This ALARA analysis is tentative because the CSM Boyertown plant is still an active facility. CSM can provide reasonable cost estimates for decontamination to the derived concentration guideline levels (DCGL). It is unrealistic, however, to expect CSM to characterize an active facility to the point that they can accurately predict how decommissioning costs will vary as functions of alternative cleanup levels. Therefore, CSM ~~prefers to~~has based the ALARA analyses on objective data~~; in~~for this situation, ~~it was necessary to~~and ma~~d~~ke reasonable ~~assumptions~~ estimates and calculations on how the decommissioning costs ~~might~~ would vary ~~with~~ with changes in the cleanup level.

The decommissioning of the site will require two general activities, structure decontamination and surface soil remediation. These activities are distinctly different in terms of the methods and the cleanup levels required. The ALARA analyses for these two work activities are necessarily different, and so they are considered individually.

ALARA Analysis for Soil Contamination

Surface soils and materials such as gravel or pavement that do not meet the DCGL will be excavated and transported to a disposal facilit~~ies~~y in the western United States that ~~are~~ is licensed to receive the types of materials removed from the site. CSM is in the final stages of establishing a contract with ~~A probable recipient is~~ the IUC facility, which is located in Blanding, Utah. Disposal fees have been agreed upon and transportation costs have been finalized, thus providing -actual costs for the basis of the DFP Cost Estimate and this evaluation.

Section N.1.5 of NUREG 1757, Volume 2 provides guidance on when the requirement for a mathematical ALARA analysis is waived. To paraphrase, it states that no ALARA analysis is required when contaminated soil will be shipped offsite for disposal at a licensed facility. NRC's rationale for waiving ALARA consideration is that generic analyses have shown that further remediation, below the DCGL, is ~~seldom~~ not cost effective. The DFP Cost ~~estimate~~ Estimate uses the costs to ship and dispose of the soils and materials at Blanding, UT because CSM ~~expects to use~~has negotiated final rates with that site and has actual cost information for shipping and disposal fees. ~~The unit cost at the Blanding site is somewhat lower than typical fees at a low-level waste disposal facility such as Envirocare of Utah.~~ These costs are ~~nonetheless~~ founded on existing agreements that are significant and sufficient to meet the intent of this NRC exemption for soils shipped to licensed disposal facilities, as the total estimated cost exceeds $4 million in Table 11 of Appendix B in the cost estimate. Consequently, no detailed ALARA analysis is required for surface soil remediation at the CSM Boyertown facility.

ALARA Analysis for Decontamination of Structures

Structures where licensed activities have occurred at CSM's Boyertown plant will be surveyed and will be decontaminated to meet free release limits prior to license termination. ~~It is a given that~~The following conditions apply:

(1) all process equipment will be removed and either be disposed as radioactive waste or decontaminated and free released in accordance with NRC Regulatory Guide 1.86 and

(2) all affected areas inside of structures will be vacuumed and/or pressure washed to remove as much loose contamination as possible.

The chief variables that affect the cost of structure decontamination are:

- ~~Lower cleanup levels translate to increased final status survey costs. This is reasonable since the minimum detectable activity for a scan decreases with the square of the count time. Increasing the count times by 33%, which would significantly increase the monitoring costs, will result in reducing MDAs to only 86.7% of the initial MDA.~~
- Lower cleanup levels result in increased costs for remediation, transportation and disposal. These costs are assumed to be approximately proportional to F. This is reasonable since the volume of waste generated will increase as F increases.
- Lower cleanup levels translate to increased final status survey costs. This is reasonable since the minimum detectable activity for a scan decreases with the square of the count time. Increasing the count times by 33%, which would significantly increase the monitoring costs, will result in reducing MDAs to only 86.7% of the initial MDA.
- Continuing plant operations are less efficient while license termination activities are occurring causing increased operational costs and decreased revenues.

Mathematical ALARA Analysis for Structure Decontamination.

The derived concentration guideline equivalent to the average concentration of residual activity that would give a dose of 25 mrem/y to the average member of the critical group (DCGLw) for gross beta activity due to ore dust under the building occupancy scenario is 323 dpm/100 cm^2, as established in section 4 of the DFP Cost Estimate. This ALARA analysis will consider the question of whether it is feasible to impose a lower dose criterion for gross beta activity. In this calculation, f is the fraction of contamination that remains, while **F** is the fraction that is removed. The relationship between thes variables is represented as:

$$F = 1 - f.$$

Default values that are acceptable to NRC were taken from Table N.2 "Acceptable Parameter Values for Use in ALARA Analyses" and used in this analysis. These values are ~~duplicated~~ presented below in Figure 1.

Figure 1. NRC Default Values for ALARA Analysis.

$fw := 4.2 \times 10^{-8}$ / hour	(*worker accident rate*)
$ft := 3.8 \times 10^{-8}$ / km	(*transport fatal accident rate*)
$cf := \dfrac{2000\ \text{dollar}}{\text{person rem}}$	(*dollars per person rem*)
$r := 0.07$ / year	(*monetary discount rate*)
$n := 70$ year	(*building life in years*)
$pd := 0.09$ person / $meter^2$	(* building population density*)
$vship := 13.6 \dfrac{meter^3}{shipment}$	(* waste volume per shipment*)
cfa: $3000000	(*cost of a fatal accident*)

Site-specific costs are provided in Figure 2. The site-specific parameters are ~~based on~~taken from the cost estimate~~ in the decommissioning funding plan~~, but have been simplified by omitting the factors that will insignificantly impact the outcome of this evaluation to prevent the ALARA analysis from becoming unduly complicated. The fully burdened cost for the scabbling was calculated using the labor rates, hours, packaging costs, transportation costs, and disposal fees for the scabbling activities in the DFP Cost Estimate. The cost per metric ton of scabbling waste produced was established using volumes from Table 2 and unit costs from Tables 4, 5, 7, 9, and 11 of the cost estimate to represent the volume of material and costs that apply only to the scabbling material. It will cost $64,000 to remove, package, manifest, transport, and dispose of the 12.2 metric tons of scabbling waste that were estimated. This cost per metric ton of scabbling wasteis represented ~~in~~ by the following term and is also listed in Figure 2.

$$\frac{64000\ \mathbf{dollar}}{12.2\ \mathbf{MetricTon}}$$

Figure 2. Site Specific Parameters for ALARA Analysis.[1]

$f := 0.867$ (*fraction of contamination that remains*)

$\mathrm{FSStf} := 1.33$ (* Final status survey incremental time factor *)

$\mathrm{dt} = 2087\,\frac{\mathrm{mile}}{\mathrm{way}} \times \frac{2\,\mathrm{way}}{\mathrm{shipment}} \times \frac{0.621\,\mathrm{km}}{\mathrm{mile}}$ (* Boyertown to Farmington, NM distance: *)

$\frac{2592.05\,\mathrm{km}}{\mathrm{shipment}}$

$\mathrm{va} = 12.2\,\mathrm{MetricTon} \times \frac{13.6\,\mathrm{meter}^3}{20\,\mathrm{MetricTon}} \times (1 - f)$ (* incremental volume of scabbling dust: *)

$1.10337\,\mathrm{meter}^3$

$\mathrm{tc} = 12800\,\frac{\mathrm{dollar}}{\mathrm{shipment}} \times \frac{\mathrm{shipment}}{13.6\,\mathrm{meter}^3}$ (* transportation cost/meter^3 *)

$\frac{941.176\,\mathrm{dollar}}{\mathrm{meter}^3}$

$\mathrm{cc} = \frac{\mathrm{shipment}}{13.6\,\mathrm{meter}^3} \times 390\,\frac{\mathrm{dollar}}{\mathrm{shipment}}$ (* container cost/meter^3 *)

$\frac{28.6765\,\mathrm{dollar}}{\mathrm{meter}^3}$

$\mathrm{dc} = 650\,\frac{\mathrm{dollar}}{\mathrm{MetricTon}} \times \frac{20\,\mathrm{MetricTon}}{13.6\,\mathrm{meter}^3}$ (* disposal cost / meter^3 *)

$\frac{955.882\,\mathrm{dollar}}{\mathrm{meter}^3}$

$\mathrm{es} := 646\,\frac{\mathrm{dollar}}{\mathrm{day}}$ (* personal protective equipment and supplies *)

$\mathrm{decon} = \frac{64000\,\mathrm{dollar}}{12.2\,\mathrm{MetricTon}}$ (* scabbling cost *)

$\frac{5245.9\,\mathrm{dollar}}{\mathrm{MetricTon}}$

$\mathrm{area} = 84770\,\mathrm{foot}^2 \times \left(\frac{0.303\,\mathrm{meter}}{\mathrm{foot}}\right)^2$ (* floor area requiring decon *)

$7782.65\,\mathrm{meter}^2$

$\mathrm{RadTechHours} := 1426\,\mathrm{hour}$ (* final status survey rad tech hours for structures *)

$\mathrm{SiteMgrHours} = \mathrm{RadTechHours} / 3$

$\frac{1426\,\mathrm{hour}}{3}$

$\mathrm{RadSuperHours} = \mathrm{RadTechHours} / 3$

$\frac{1426\,\mathrm{hour}}{3}$

$\mathrm{PlantDepreciationExpense} := 7 \times 10^6\,\frac{\mathrm{dollar}}{\mathrm{year}} \times \frac{\mathrm{year}}{2080\,\mathrm{hour}}$ (* Depreciation Expense, unlicensed activities *)

$\frac{3365.\,\mathrm{dollar}}{\mathrm{hour}}$

---

[1] The relationship between FSStf and f is assumed to be:

$\left(\frac{1}{f}\right)^2 - \mathrm{FSStf} == 0$

There are 13 factors described in Table 2 that are used to define the site-specific parameters for this ALARA analysis. The individual values that are used to define each of those 13 factors are taken directly from tables in the cost estimate. It should be noted that the third parameter, "Boyertown to Farmington, NM distance" is used to represent the transportation distance for material that will be sent to IUC in Utah. Farmington,NM was used as the end point in estimating this distance (2087 miles) because it was the nearest identifiable rail station location to the Utah location and provided a reasonably accurate, yet conservative value for the distance the waste is transported.

Incremental costs of decontamination, equipment and supplies, and labor for decontamination and final status survey are taken from the cost estimate and provided in Figure 3. In Figures 2 and 3, the following term is a unit conversion factor that represents the net weight per truckload of scabbling dust divided by its volume using the values for trucks taken from the DFP Cost Estimate:

$$\frac{20\,\text{MetricTon}}{13.6\,\text{meter}^3}$$

Figure 3. Incremental costs of decontamination, equipment and supplies, and labor for decontamination and final status survey.

$$\text{DecontaminationCost} = \text{decon} \times \text{va}\,\frac{20\,\text{MetricTon}}{13.6\,\text{meter}^3} \quad \text{(* Scabbling and decontamination *)}$$

8512. dollar

$$\text{MaterialEquipmentCost} = \text{es} \times \frac{\text{SiteMgrHours}}{8\,\text{hour / day}} \times (\text{FSStf} - 1) \quad \text{(* Equipment and supplies *)}$$

12666.4 dollar

FSSLabor =

$$(\text{FSStf} - 1) \times \left(\left(\text{SiteMgrHours} \times \frac{63\,\text{dollar}}{\text{hour}}\right) + \left(\text{RadTechHours} \times \frac{65\,\text{dollar}}{\text{hour}}\right) + \left(\text{RadSuperHours} \times \frac{78\,\text{dollar}}{\text{hour}}\right)\right)$$

52705. dollar

$$\text{crem} = \text{DecontaminationCost} + \text{MaterialEquipmentCost} + \text{FSSLabor} \quad \text{(* total remediation and FSS cost *)}$$

73883.4 dollar

Figure 3 identifies labor costs for three categories of workers used in the cost estimate: a site manager, a radiological supervisor, and a radiological technician. It is assumed in the cost estimate, and shown in Figure 3, that there are three rad techs and one site manager in each work group. Unit and incremental transportation and disposal costs were calculated from the tables in the DFP Cost Estimate and are provided in Figure 4.

Figure 4. Unit and incremental transportation and disposal costs.

Unit Transportation and Disposal Cost, **costv**

$$\mathbf{costv} = \mathbf{tc} + \mathbf{cc} + \mathbf{dc}$$

$$\frac{1925.74\ \text{dollar}}{\text{meter}^3}$$

Incremental transport and disposal monetary costs, **ctwd**

$$\mathbf{ctwd} = \mathbf{costv} \times \mathbf{va}$$

2124.79 dollar

One term in the equation provided by the NRC in section N.1.2 of Appendix N is "other costs as appropriate for the particular situation". ~~On p~~Page N-9 of that appendix provides clarification of the types of other costs that are typical for this term of the equation, including "Loss of Economic Use of the Property". Such loss of economic use is relevant for the particular situation at CSM because several production operations at the Boyertown site do not depend on the processing of source material and are expected to remain economically viable during D&D activities.[2] Those operations will be adversely impacted by the D&D activities. ~~An estimate of the incremental costs related to decreased efficiency of ongoing plant operations during D&D activities is provided in Figure 5.~~ It is assumed that the efficiency of ongoing plant operations is reduced to 98% of normal during the period when D&D activities are conducted. This is based only on the estimated hourly depreciation expense for plant equipment that is used for unlicensed activities. Of course this cost will increase if the incremental cost of lower labor efficiency is also included, or if critical plant systems such as the wastewater treatment plant must be taken off-line for a significant period of time. These other cost impacts are noted as defense in depth, but they are not specifically included in the ALARA calculation, which is simplified to include only the hourly depreciation expense. An estimate of the incremental costs related to decreased efficiency of ongoing plant operations during D&D activities is provided in Figure 5.

Figure 5. Incremental costs related to loss of plant efficiency during decontamination and decommissioning.

$$\mathbf{cother} = \mathbf{PlantDepreciationExpense} \times (\mathbf{FSStf} - 1) \times \mathbf{SiteMgrHours} \times 0.02$$

10557.9 dollar

Figure 6 shows costs that could be accounted for in accordance with the guidance in Appendix N of NUREG-1757, Vol. 2, but were neglected to simplify the calculation. It is CSM's prerogative to exclude these costs from the ALARA analysis because they are insignificant when compared to the factors that remain in the calculation and would not materially effect the result.

Figure 6. Negligible incremental costs.

[2] In addition to extraction of tantalum from ore, the Boyertown plant makes specialty tantalum, niobium and titanium compounds. Milling activities at the plant include the preparation of specialty alloys of zirconium, niobium and tantalum as thin film, wire, and bar stock and other forms. The plant also houses CSM's Research and Development Group.

Incremental worker accident monetary cost, cwacc, is small and is rounded to zero.

cwacc := 0

Incremental traffic fatalities monetary cost, ctf, is small and is rounded to zero.

ctf := 0

Incremental worker dose monetary cost, cwdose

cwdose := 0

Incremental monetary cost of public dose, cpdose

cpdose := 0

Figure 7 provides the total incremental increases in final status survey costs that result from increasing the count time by 33%, which would significantly impact decommissioning costs. ~~and thereby~~ That change would reduce~~ing~~ the contamination levels from 323 dpm/100 cm^2 to ~~86.7%~~280 dpm/100 cm^2, a 13% reduction of the DCGL~~, which is~~that was based on 25 mrem/year.

Figure 7. Total incremental cost of reducing contamination levels to 86.7% of the DCGL.

totalcost = crem + ctwd + cwacc + ctf + cwdose + cpdose + cother

86566.1 dollar

Figure 8 provides the ratio of cost over DCGL below which it is not ALARA to further decrease residual contamination levels. Figure 8 shows that the ratio is greater than 1, so it is not ALARA to reduce doses below about 33 mrem/year. However, CSM will exceed the ALARA requirements and reduce contamination levels to the regulatory limit of 25 mrem/year. CSM also commits to pressure washing the affected areas within buildings where licensed activities occurred.

Figure 8. Ratio of concentration to DCGL below which it is not ALARA to further reduce contamination levels.

$$\mathrm{ConcOverDCGL} = \frac{\mathrm{totalcost}}{\mathrm{cf} \times (1 - \mathrm{f}) \times 0.025\,\frac{\mathrm{rem}}{\mathrm{year}} \times \mathrm{area} \times \mathrm{pd} \times \frac{1 - e^{-r \times n}}{r}}$$

1.31069

APPENDIX A

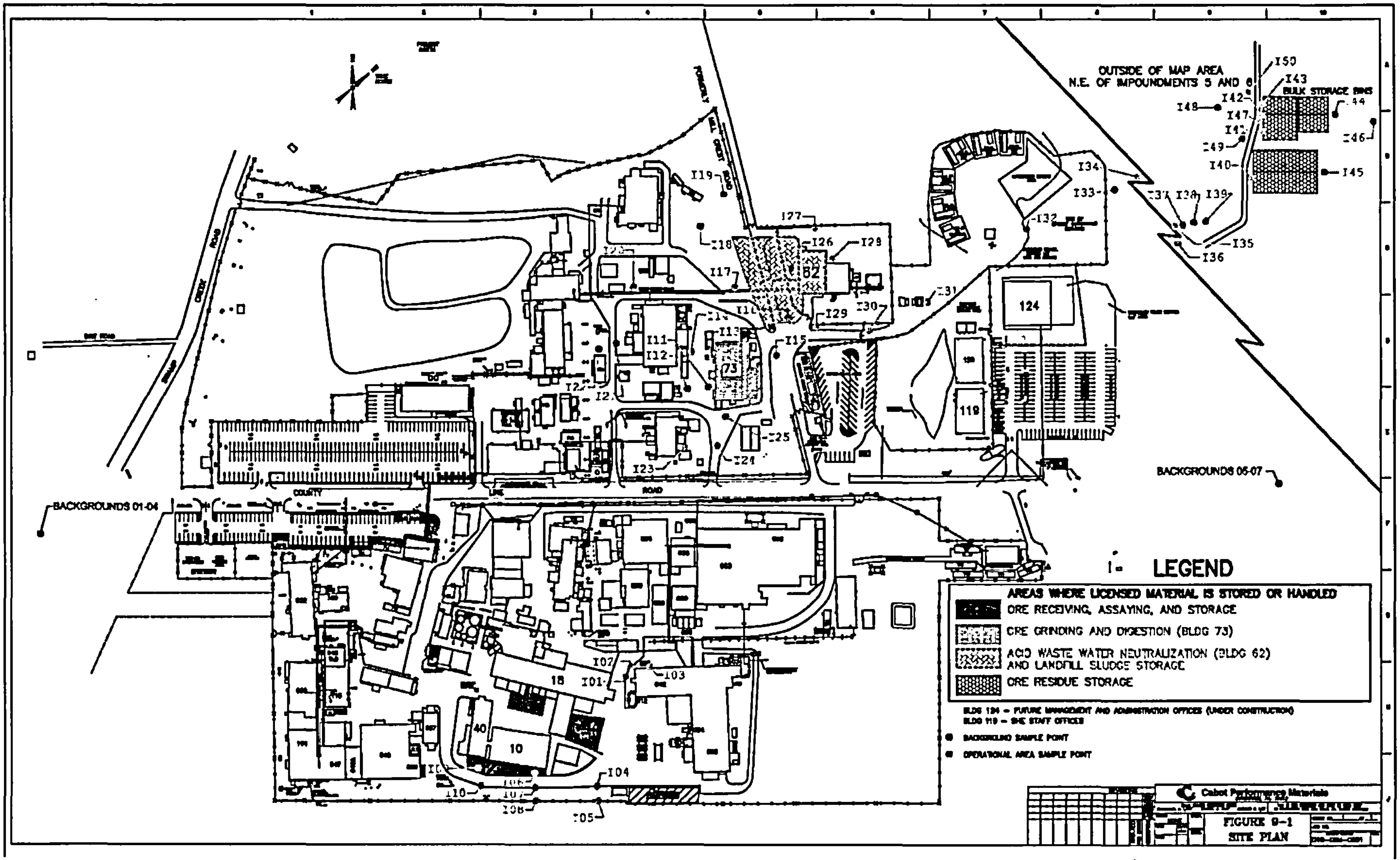


FIGURE 9-1
SITE PLAN

APPENDIX B

Table 1. A.3.5 Number and Dimensions of Facility Components

Building or Area	Description	Number of Components	Mass (lb)	Volume (ft^3)	Reference*
73	Digester System	322	22492	419	1
73	Filter Sludge Storage Area	12	9814	640	2
73	Filtration System	129	30428	2741	1
73	Kiln System	37	15218	378	1
73	Ore Grinding System	141	49361	4285	1
73	Outside Feed Tank Area	6	8892	1028	2
73	Outside Grinding Bag Filter Area	22	12812	183	2
73	Outside Kiln Bag Filter Area	17	3114	341	2
73	Outside Off-gas Scrubber System	68	9568	410	2
73	Roof Ore Classifier System	19	3203	298	2
73	Tanks	28	76523	6879	4
74	Extraction Systems	42	4011	82	2
74	Tanks	10	12936	5500	4
All	Pipe, conduit, stair railing	48	87583	1170	3
Bulk Storage Bins	Miscellaneous hardware	121	1760	539	2
Thorium doping systems	Miscellaneous (HEPA vac, ducts, 2 tables)	3	400	15	Current estimate
Total debris			**348,115**	**24,908**	

* Pages from Appendix 5 of 1993 SEG cost calculation sheets for the Boyertown Site.

Table 2. A.3.5 Number and Dimensions of Facility Buildings

Building or Area	Description	Area (ft^2)	% Contaminat	Depth (in)	Volume (ft^3)	Reference*
73	Ceiling	13585	0	0	0	6
73	Floor	13585	100	0.25	283	6
73	Wall	16285	100	0.25	339	6
74	Ceiling	13585	0	0	0	6
74	Floor	13900	100	0.25	290	6
74	Wall	16285	100	0.25	339	6
87	Ceiling	13585	0	0	0	6
87	Floor	3440	100	0.25	72	6
87	Wall	22760	66	0.25	313	6
99&102	Ceiling	53845	100	0.25	1122	6
99&102	Floor	53845	100	0.5	2244	6
99&102	Wall	35866	100	0.25	747	6
Bulk storage bins	Soil	62500	100	12	62500	Current estimate
Thorium doping room	Ceiling	64	0	0	0	Current estimate
Thorium doping room	Floor	64	100	0.25	1	Current estimate
Thorium doping room	Wall	256	100	0.25	5	Current estimate
Winter Slag Storage	Slab	2558	100	0.5	107	6
Building 73/74/87 soil	Soil	62500	100	12	62500	Current estimate
Haul road	Soil	56000	100	12	56000	Current
Total		454,508			186,862	

* Pages from Appendix 5 of 1993 SEG cost calculation sheets for the Boyertown Site, or other source.

Table 3. A.3.7 Dismantling of Radioactive Facility Components (Hours)

Building or Area	Description	Decon Method	Rad Tech	Demolition Worker	Heavy Equipment Operator	Rad Supervisor	Site Manager
73	Digester System	Remove, size, place in roll-offs	4	4	2	1	1
73	Filter Sludge Storage Area	Remove, size, place in roll-offs	6	6	3	2	2
73	Filtration System	Remove, size, place in roll-offs	27	27	14	9	9
73	Kiln System	Remove, size, place in roll-offs	4	4	2	1	1
73	Ore Grinding System	Remove, size, place in roll-offs	43	43	21	14	14
73	Outside Feed Tank Area	Remove, size, place in roll-offs	10	10	5	3	3
73	Outside Grinding Bag Filter Area	Remove, size, place in roll-offs	2	2	1	1	1
73	Outside Kiln Bag Filter Area	Remove, size, place in roll-offs	3	3	2	1	1
73	Outside Off-gas Scrubber System	Remove, size, place in roll-offs	4	4	2	1	1
73	Roof Ore Classifier System	Remove, size, place in roll-offs	3	3	1	1	1
73	Tanks	Remove, size, place in roll-offs	69	69	34	23	23
74	Extraction Systems	Remove, size, place in roll-offs	1	1	0	0	0
74	Tanks	Remove, size, place in roll-offs	55	55	28	18	18
All	Pipe, conduit, stair railing	Remove, size, place in roll-offs	12	12	6	4	4
Bulk Storage	Miscellaneous hardware	Remove, size, place in roll-offs	5	5	3	2	2
Thorium doping systems	Miscellaneous (HEPA vac, ducting, 2 tables)	Remove, size, place in roll-offs	0	0	0	0	0
Totals			249	249	125	83	83

Table 4. A.3.7 Unit Labor Factors

Unit Labor Factors (hours per ft^2 or ft^3)						
Operation	**Rad Tech**	**Decon Tech**	**Demolition worker**	**Rad Superv (1)**	**Heavy equip operator**	**Site Manager**
Pressure Washing (2)	1.7E-03	1.7E-03	0	5.56E-04	0	5.56E-04
Scabbling (3)	1.00E-02	1.00E-02	0	3.33E-03	0	3.33E-03
Excavation (4)	5.00E-04	0	0	1.67E-04	5.00E-04	1.67E-04
Final Status (5)	5.00E-03	0	0	1.67E-03	0	1.67E-03
Remove, size equip't & debris(4)	1.00E-02	0	0.01	3.33E-03	5.00E-03	3.33E-03

(1) 1 Rad Supervisor per 3 rad techs

(2) Pressure washing rate of 600 ft^2 per hour

(3) Scabble or remove/size eqpt/debris rate of 100 ft^3/hour

(4) Excavation rate of 2000 ft^3 per hour

(5) Final status survey rate is 200 ft^2/hour

Table 5. A.3.7 Decontamination of Radioactivity Facility Components (Hours)

Building	Description	Flag 1-Pressure wash, Grit blast, Vacuum (1=yes, 0=no)	Flag 2:Scabble, chip (1=yes, 0=no)	Flag 3: Excavate (1=yes, 0=no)	Rad Tech	Decon Tech	Heavy Equipment Operator	Rad Supervisor	Site Manager
73	Ceiling	1	0	0	23	23	0	8	8
73	Floor	1	1	0	25	25	0	8	8
73	Wall	1	1	0	31	31	0	10	10
74	Ceiling	1	0	0	23	23	0	8	8
74	Floor	1	1	0	26	26	0	9	9.
74	Wall	1	1	0	31	31	0	10	10
87	Ceiling	1	0	0	23	23	0	8	8
87	Floor	1	1	0	6	6	0	2	2
87	Wall	1	1	0	41	41	0	14	14
99&102	Ceiling	1	0	0	90	90	0	30	30
99&102	Floor	1	1	0	112	112	0	37	37
99&102	Wall	1	1	0	67	67	0	22	22
Bulk Storage Bins	Soil	0	0	1	31	0	31	10	10
Thorium doping room	Ceiling	1	0	0	0	0	0	0	0
Thorium doping room	Floor	1	1	0	0	0	0	0	0
Thorium doping room	Wall	1	1	0	0	0	0	0	0
Winter Slag Storage	Slab	1	1	0	5	5	0	2	2
Building 73/74/87 soil	Soil		0	1	31	0	31	10	10
Haul road	Soil		0	1	28	0	28	9	9
Total hours					594	503	91	198	198

Table 6. A.3.8 Restoration of Contaminated Areas

Building	Description	Heavy Equipment Operator
Bulk Storage Bins	Soil	31.25
Building 73/74/87 soil	Soil	31.25
Haul road	Soil	28
Total hours	0	90.5

Table 7. A.3.9 Final Radiation Survey (Work Hours)

Building	Description	Rad Tech
18, 10, 23, 11, 41, 62	Floors/soil	142.5
73	Ceiling	67.925
73	Floor	67.925
73	Wall	81.425
74	Ceiling	67.925
74	Floor	69.5
74	Wall	81.425
87	Ceiling	67.925
87	Floor	17.2
87	Wall	113.8
99&102	Ceiling	269.225
99&102	Floor	269.225
99&102	Wall	179.33
Bulk storage facility	Soil	312.5
Thorium doping room	Ceiling	0.32
Thorium doping room	Floor	0.32
Thorium doping room	Wall	1.28
Winter Slag Storage	Slab	12.79
73/74 soil	Soil	312.5
Haul road	Soil	280
Total hours		2415.04

* Excludes Rad Supervisor, Site Manager, and CHP. Their costs show as factored values in Tables 8 and 10.

Table 8. A.3.11 Total Work Hours by Labor Category

Man Hours by Task							
Task	Rad Tech	Decon Tech	Demolition worker	Rad Supervisor	Heavy equip't operator	Site Manager	CHP
Planning and Preparation	0	0	0	100	0	100	200
Decon & Dismantling	843	503	249	281	215	281	0
Restoration*	0	0	0	0	30	30	0
Final Status	2,415	0	0	805	0	805	100
Total	**3,258**	**503**	**249**	**1,186**	**245**	**1,216**	**300**

*Recontouring is estimated at 1/3 the excavation time

Table 9. A.3.12 Worker Unit Cost Schedule

	Rad Tech	Decon Tech	Demolition worker	Rad Superv	Heavy equip operator	Site Manager	CHP
Fully loaded hourly billing rate	$64	$35	$26	$78	$37	$63	$133
Total Cost per day	$514	$278	$206	$623	$294	$504	$1,062

Table 10. A.3.13 Total Labor Costs by Major Decommissioning Task

Activity	Rad Tech	Decon Tech	Demolition worker	Rad Superv	Heavy equip't operator	Site Manager	CHP
Planning and Preparation	$0	$0	$0	$7,788	$0	$6,300	$26,550
Decon & Dismantling	$54,109	$17,513	$6,426	$21,880	$7,903	$17,699	$0
Restoration	$0	$0	$0	$0	$1,109	$1,901	$0
Final Status Surveys	$155,046	$0	$0	$62,694	$0	$50,716	$13,275
Total	$209,155	$17,513	$6,426	$92,362	$9,011	$76,616	$39,825

Table 11. A.3.14 Packaging, Shipping, and Disposal of Radioactive Material (Excluding Labor Costs)

Waste Type	Material Quantity (MT)	Number of Containers	Type of Container (20 cu yd)	Container Unit Cost	Total Packaging Costs
Debris	158	2	Roll-off Bin	$390	$899
Scabbling Dust & Soil	422	17	Roll-off Bin	$390	$6,748
Presscake	3628	269	Roll-off Bin	$390	$104,809
Total					$112,456
B. Shipping Costs					
Waste Type	Number of Loads	Cost per Load Truck/train ($)	Total Cost		
Debris	2	$12,800	$29,521		
Scabbling Dust & Soil	17	$12,800	$221,466		
Presscake	296	$8,640	$2,557,440		
Total			$2,808,426		
C. Disposal Costs					
Waste Type	Disposal Quantity (MT)	Unit Cost ($/MT)	Surcharge	Total Disposal Costs	
Debris	158	$650		$102,852	
Scabbling Dust & Soil	422	$259	$66	$137,310	
Presscake	3628	$259	$66	$1,180,000	
Total				$1,420,162	

Table 12. A.3.15 Equipment/Supply Cost (Excluding Containers)

Equipment & Supplies	Quantity days	Unit Cost ($/day)	Total Equipment and Supply Cost
Crane	30	$347	$10,414
Front end loader/Backhoe	60	$122	$7,327
Cherry Picker	60	$37	$2,241
Expendables	870	$39	$33,918
Rad Equipment	90	$100	$9,000
Total			$62,900

Table 13. A.3.16 Laboratory Costs

Activity	Total Cost
Gamma Spec	$30,400
Shipping	$1,000
Total	$31,400
Based on 400 samples	

Table 14. A.3.17 Miscellaneous Costs

Cost Item	Total Cost
Mob/Demob	$50,000
Total	**$50,000**

Table 15. A.3.18 Total Decommissioning Cost

Task Component	Cost	% of Total
Planning/Preparation (Table 10)	$40,638	0.8
Decon & Dismantling (Table 10)	$125,530	2.4
Restoration of Contaminated Areas (Table 10)	$3,009	0.1
Final Status Surveys (Table 10)	$281,731	5.5
Site Stabilization and Long Term Surveillance	$0	0.0
Volume Reduction Costs	$138,416	2.7
Packing Material Costs (Table 11)	$112,456	2.2
Laboratory Costs (Table 13)	$31,400	0.6
Miscellaneous Costs (Table 14)	$50,000	1.0
Equipment /Supply Costs (Table 12)	$62,900	1.2
Subtotal	$846,081	
Pennsylvania Sales Tax (6%)	$50,765	1.0
Transportation Costs (Table 11)	$2,808,426	54.8
Waste Disposal Costs (Fees) (Table 11)	$1,420,162	27.7
Full Subtotal	$5,125,433	
15% Contingency	$768,815	
Total Decommissioning Cost Estimate	**$5,894,248**	100.0